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SIR JOSEPH COWEN.

SIR JOSEPH COWEN, AND THE IMPROVEMENT OF THE TYNE.

TO the great bulk of our own countrymen the Tyne is known chiefly, if not solely, as an outlet of the great northern coal-field. It is only the few who are acquainted with its remarkable history, with the rapid and stupendous growth of its trade, with the enterprise, energy, and engineering skill that were employed to make it what it is, not because, but in spite of its natural characteristics, and of the prospects that lie before it. The trade of the Tyne is larger than that of any other river in the United Kingdom, except the Mersey. Its resources are practically illimitable. What with the millions on millions of tons of coal that surround it, and furnish it with the nucleus of a shipping trade more substantial and certain of increase than that owned by any other river, with the immense capital at the disposal of those who are primarily interested in its development, and the circumjacent accessories of commerce and industry that have recently been created, and beside the aggregate of which even the coal trade threatens to hide its diminished head, it may be fairly claimed for the Tyne that it has an outlook bounded only by imperial considerations of the first magnitude, and that within the span of the present generation it will take a much higher rank than it has yet done in the trade and navigation returns of the United Kingdom.

The improvement of the river Tyne has been quite a modern undertaking. It was projected originally on a very small scale, and for the limited purpose of affording better facilities of shipment to the small coasting craft that then frequented the river to take in cargoes of coal. Distinguished as is the main artery of the great northern coal-field, the Tyne has, nevertheless, had competitors. The Wear, six miles farther south, has had equal and in some respects even better chances of development; and twenty miles farther south there is the Tees, which ought to be the great outlet for the South Durham coal-field, according to its geographical situation, but which has always been very far behind the Tyne in the extent of its coal shipments. It seemed at one time as if the port of Hartlepool were to take precedence of the Tyne. The £100 shares of the old Hartlepool dock and

railway were selling at £180 when an arrangement was effected with Mr. George Hudson, the railway king, by which it was stipulated that the North-Eastern Railway Company should lease the dock and line for thirty years, and pay the shareholders eight per cent. interest. Not long afterwards, Mr. R. Ward Jackson and other influential gentlemen projected the West Hartlepool Docks and Railway, and invested a sum of £3,250,000 in docks, railroads, collieries, and ships. The sceptre did not, however, long remain with the Hartlepools; and even the North-Eastern Railway Company came to find that their interests were more bound up in the Tyne than in any other river.

Sixteen years ago, an able engineer, resident in Newcastle,[1] calculated that the Durham coal-field, with its 470 square miles, would at the then rate of working (15,250,000 tons per annum) last for 222 years to come; and by adding the 7,000,000 tons annually drawn from the 280 square miles in Northumberland, there was an aggregate annual yield of 22,250,000 tons, which was the then rate of the working out of the whole 800 square miles, containing about 200 working pits in the best positions. "Deducting," he added, "one half of the whole for home or local consumption, there remains about 11,000,000 tons to be shipped yearly, nearly 5,000,000 tons of which are placed on board in the Tyne, and the remaining 6,000,000 tons in the other eight or nine rivers, harbours, and ports on the coast. But the probability is, that if these good coal-producing districts continue to increase their trade as they have done during the last five or six years, the Tyne and adjoining ports will be benefited much more rapidly, while the coal-fields will diminish in the like ratio."

It was calculations like these that led the Commissioners of the Tyne Conservancy to undertake the improvement of the river to an extent that has involved the outlay of between £3,000,000 and £4,000,000.

This expenditure has not failed of its desired result. From the condition of a brawling stream, full of rocks, shoals, and other obstructions, offering to navigation impedimenta of the most serious kind, the Tyne has become one of the most splendid and complete navigable highways in the United Kingdom.

It is not our purpose here to speak of the Tyne previous to the year 1850 at great length. The Tyne Improvement Act of that year transferred the control of the river from the corporation of Newcastle to a body of which, within three years after its formation, Sir Joseph Cowen was appointed chairman. The recipient of this honour was in every sense worthy of it. No one had worked more zealously for the establishment of the new trust. The movement for the withdrawal from the corporation of the control of the river conservancy was initiated by the people of North and South Shields, who objected that the revenue belonging to these ports should be expended in improving and beautifying the streets of Newcastle; and also that the corporation should sanction such half-hearted and imperfect operations as were then carried on. When, therefore, a bill was promoted in Parliament with the object of securing the proposed transfer of the management of the river to an elective body, composed of representatives of all the communities upon its banks, and selected in such a proportion as to secure the conservation of the whole river from the sea up to its tidal boundary, Sir Joseph (then Mr.) Cowen supported the project, and arduously exerted himself to secure for the inhabitants along the western reaches of the river a fair representation on the new board, maintaining that as one half of the navigable channel of the Tyne lay westward of Newcastle, it was but fair that the western portion of the river, as well as the Shields ports and Gateshead, should share with Newcastle the right of being represented on the proposed board. In addition to holding local meetings to agitate the subject, he appeared before the commission appointed to inquire into the navigation of the river, and he offered evidence before a committee of the House of Commons in favour of the bill. Sir Joseph did not succeed to the full extent of his wishes. The House of Commons Committee could not fix a constituency in the scattered and unorganized western villages for which Sir Joseph claimed representation; but it was provided that all the corporate bodies on the Tyne should be represented on the new commission, and Sir Joseph Cowen was made a life member.

From this time forward to the time of his death, the annals of the Commissioners of the Tyne Conservancy are to a large extent a history of the public life of Sir Joseph Cowen. With boundless faith in the resources of the Tyne, and its susceptibility of improvement, he did not hesitate to recommend schemes of such magnitude and thoroughness, that their projection was not unfrequently deprecated as being in advance of the requirements of the shipping interest, and more costly than the financia circumstances of the river could afford. Throughout the whole range of river engineering, there is no more brilliant example of the results capable of being achieved by skill and energy, backed by an almost unlimited amount of capital. The only two great rivers that rival the Tyne in extent of trade, have been from time immemorial navigable highways possessed of all the advantages that nature can confer. Much has been done for the Clyde by the trust that now presides over its destinies, assisted by the advice and co-operation of the most distinguished engineers of the day; but although it is perfectly true that opposite Kelvinghaugh and up almost to the Broomielaw itself it was possible within living memory to ford the Clyde on foot, below these points the great highway of western Scotland had a channel wide enough and deep enough for nearly all the ordinary purposes of shipping, while opposite Dumbarton it opened out into a splendid estuary, upon the bosom of which a whole navy might safely and easily repose. The Wear, also, which is the only formidable rival of the Tyne in the north of England, has owed not a little to engineering science. But the improvements effected in the navigation of the Wear have all, or nearly all, been confined to within a couple of miles of its confluence with the German Ocean, and to the construction of docks within a few yards of the open sea, while the Tyne has been made a deep and spacious harbour, nearly twenty miles long, and varying from 400 ft. to 1,400 ft. in width. The Tees is another river that has been rescued by engineering science from a natural condition inimical to the safety of shipping, and converted into a noble maritime highway, with a splendid future in prospect; but the length of the Tees, from the bar to its tidal boundary, is not much more than one half the length of the Tyne; and where the Tees commissioners have expended their thousands, the commissioners of the Tyne have spent their tens of thousands. Most of the other navigable rivers of England have more or less had depth, width, and safety secured to them as a natural heritage, much the same as the Thames and the Mersey, so that for the Tyne it may be claimed that it stands almost alone in its obligations to science, enterprise, and capital, and in having been enabled by these media to take rank, along with rivers more highly favoured by nature, as one of the main arteries of England's trade and commerce.

Let us, however, consider somewhat more in detail the successive improvements that have made the Tyne what it is to-day. A survey of the river, made in 1849, elicited the following, among other facts:—

That though 95 acres of the tidal basin of the Tyne, or about one-sixteenth of the high-water superficies of the river, had been converted into land, the detached and principal sand-banks had increased in area from 99 to 104 acres.

That notwithstanding this restriction of size, the tidal development was uninfluenced; thus, on the 13th May, 1813 (two days after the new moon), the tide rose 14 ft. 11 in. at North Shields, and 11 ft. 8 in. at Newcastle; while on the 21st July, 1849 (also two days after the new moon), the tide rose 15 ft. at North Shields, and 11 ft. 8 in. at Newcastle, or practically the same at the two periods.

That of the 286 sections measured by Rennie in 1813 across the channel of the Tyne between Shields and Newcastle, 69 had increased, and 217 had decreased, the difference being equivalent to the loss on a common spring-tide of 34 millions and upwards of cubic feet of tidal water, nearly the whole of which was due to the formation of artificial shores and other works between Jarrow and Hebburn. The above reduction of natural and constantly-acting power is simply represented by a river a statute mile long, 500 ft. wide, and 13 ft. deep.

That the deep water track, or approximate sailing channel, between Shields and Newcastle, had been reduced in average high-water depth from 25 ft. to 24 ft. 4 in., while navigation was rendered more difficult from the track having become more broken.

That the gauge, or the measure and proof, of tidal loss was, of course, to be looked for at the lower part of the river. Accordingly, I found that North Shields Harbour was 34 ft. narrower and 3 ft. shallower than it was in 1813, while its throat, or restricted entrance, between the Low Light beach and the point of the Middle Ground, was from 30 to 40 per cent. less in its sectional low-water capacity; and

Lastly, that the low-water section of the channel across the bar, measured between similar bounding contours existing at the two periods of 1813 and 1849, had diminished a quarter part, viz. from 9,775 to 7,560 square feet.

Up, therefore, to the date of the passing of the Tyne Improvement Act in 1850, the condition of the river had been growing worse instead of better for the purposes of navigation. Let us now see what were the extent and value of the achieve-

[1] Thomas Young Hall, "On the Rivers, Ports, and Harbours of the Great Northern Coal-fields."

ments of the Tyne commission during the first twenty years of its existence, as they are set forth in a report dated the 10th of July, 1872.[1]

The depth of the channel, over the bar, which was 6 ft. 8 in. in 1849, had been increased by dredging to 15 ft. in 1865. In 1872, however, there was practically no bar, as a depth of 27 ft. existed along the track, in from the sea, till the proper channel of the river was reached.

The throat of Shields harbour, locally called the Narrows, has had the width between its high-water boundaries increased from 380 to 590 ft. to the great gain of navigation.

Hebburn Shoal, a 4 ft. obstruction in 1849, has had its site deepened to 26 ft., and Long Reach, about 2 miles in length, has had its 5 ft. shallows deepened to 19 ft. and 24 ft. A depth of 18 ft. to 25 ft. has been substituted for dry St. Peter's Sand, which formerly occupied three-fifths of the channel, and from St. Peter's to Newcastle Bridge, the navigable track has been deepened from 8 ft. or 9 ft. to about 22 ft.

In 1849 the lower portion of Shields harbour, immediately within the Narrows, was nearly wholly occupied by the Middle Ground, and its summit, the In-sand, 6 acres of the mass drying at low water. These have been removed bodily, and the sailing channel, instead of being restricted as formerly to the narrow and intricate passage along the Low Light beach, now extends completely across from shore to shore, unencumbered by a single impediment. It is interesting to know that a depth of 25 ft. to 30 ft. exists over the site of the In-sand, which dried 3 ft. in 1849, and upon which the women of South Shields commonly gleaned a harvest of drifted coal.

In 1849 the Dortwick Sand, in the upper part of Shields harbour, dried for 11 acres of its extent, and confined the navigable channel over towards the quays at South Shields. Now a depth of 23 ft. to 25 ft. is found over its site. Some idea may be formed of the remarkable changes which have been effected hereabouts, when it is mentioned, that at a spot where in 1849 there was a depth of 6 ft. only, the ironclad Swiftsure, drawing 25 ft., was berthed with 10 ft. under her keel when the tide was at its lowest, while the Wellesley training ship lies in a depth of 28 ft. where the sand dried 5 ft. in 1849.

Whitehill Sand, which stretched half-way across the channel, has been removed, and a depth of 20 ft. to 24 ft. established over its site.

About a mile further up the river, Jarrow Sand, 16 acres of which uncovered, and Jarrow Shoal, a usual sticking place to the small passenger steamers plying between Shields and Newcastle, have also been dredged away down to a general depth of 23 ft. and 24 ft. The Slip Sand, a dry patch of 4 acres, covering in Palmer's shipbuilding yard, has been similarly removed.

Such a wholesale removal of sands and other obstructions could not take place without materially affecting the tidal development. Hence Captain Calver found that high water at Newcastle occurs 23 minutes after high water at South Shields, instead of 1 hour 3 minutes, as in 1849. The surface of high water at Newcastle has also been raised by dredging operations about 6 in., and that of low water lowered 3 ft. 6 in. This marked impression upon the high and low water surfaces of the tidal column represents a gain on a common spring of 77,751,900 cubic feet of tidal water below Newcastle Bridge, and 34,103,880 cubic feet above it, or 111,855,780 cubic feet in all—an amount more than three times that of the loss which had been sustained between the years 1813 and 1849.

To secure the remarkable results above indicated dredging operations on a scale of unexampled magnitude were necessary. In 1857 the Lords of the Admiralty suggested that the Tyne commissioners should be compelled to remove 400,000 tons annually, but ten years later the commissioners were removing about twelve times that quantity. A report issued under the auspices of the commissioners in 1868 stated that, "the quantity of material removed from the bed of the Tyne during the last six years has been nearly equal in amount to the quantity of coal exported from the river during the same time." During the thirteen years ending 1850 only 493,426 tons of material had been removed from the bed of the river, but during the next eighteen years the commissioners raised no less than 29,724,221 tons! In 1866 no less than 5,273,585 tons were dredged, and although the dredging operations of the Tyne commissioners have rather slackened since that time, they are still carried on to an extent that is unapproached by any other river. It has been truly said that these results establish the Tyne as the most noteworthy example of river improvement within the bounds of the United Kingdom.

[1] Captain E. K. Calver's "Survey of Improvements effected in the River Tyne."

Under their various Acts the Tyne Improvement Commissioners have power to borrow or hold on mortgage no less a sum than £3,700,000. Of this amount some £1,397,349 are appropriated to the Tyne Improvement Fund, £1,050,000 to the Northumberland Dock Fund, £600,000 to the Tyne Pier Fund, and £35,000 to the River Moorings Fund. In addition to the amounts expended by the Tyne Improvement Commissioners, the North-Eastern Railway Company have spent on the Tyne Docks and Brandling Drops no less a sum than £750,000.

The romantic annals of commerce do not furnish a single example of progress at all comparable with that achieved by the Tyne during the period that these improvements have been in course of completion. The total value of the exports of the port of Newcastle (exclusive of coal and coke) rose from £778,472 in 1864, to £3,151,701 in 1873, and the tonnage of vessels clearing from the Tyne increased from 2,849,680 tons in 1854, to 4,611,358 tons in 1873, while the average size of vessels clearing from the port rose from 149 tons in the former year to 274 tons in the latter. Custom-house returns show that the Mersey is the only river in the United Kingdom that has a larger export trade than the Tyne, although the latter river has more vessels employed in its export trade than any other. Thus we find, that while Liverpool had 13,742 vessels clearing outwards in 1872, the Tyne port had 19,101; but the tonnage of the vessels clearing from Liverpool reached 5,569,793 tons, while that of the vessels clearing from the Tyne was only 4,885,412 tons.

Enough, and probably more than enough, has been said to prove the conclusion which our premises were intended to establish. The Tyne stands alone to-day as a monument of the enterprise, pluck, and skill of those who have been engaged in its development, and it is only doing justice to Sir Joseph Cowen to add that no man did more than he to promote the maritime greatness of the coaly river.

In recognition of his labours on behalf of the Tyne, Sir Joseph Cowen received the honour of knighthood from Mr. Gladstone.

General Biography of Sir Joseph Cowen.

Although his labours in connection with the improvement of the Tyne form the most conspicuous, they do not present the most remarkable phase of Sir Joseph Cowen's career. Like most of the industrial magnates of the north of England, he was essentially a self-made man. From being a journeyman chainmaker at the works of the Messrs. Hawkes at Gateshead, he rose to be senior member of Parliament for the town of Newcastle, and the recipient of a knighthood. Between these two extreme points a life was lived of unflagging industry and integrity, full of lofty principle, of zealous public service, and of unceasing strife on behalf of that freedom which he largely assisted in enabling to

> "broaden slowly down
> From precedent to precedent."

About the year 1823 or 1824 Sir Joseph quitted the factory where he laboured as a journeyman to join his brother-in-law, Mr. Anthony Foster, in a fire-brick business at Blaydon Burn. Beginning here as general manager, he soon was admitted into partnership, and ultimately acquired complete possession of the property. But he was something more than a fire-brick manufacturer; he was one of the most notable pioneers of that industry. Upon the investigation of the chemical properties of the raw material he bestowed so much attention that he was enabled, by mixing and tempering the various kinds and qualities of clay, to produce a fire-brick capable of standing a large amount of heat. At the time that Sir Joseph Cowen became connected with it, the fire-brick trade was in its infancy. In 1838 it was calculated that there were not more than 7,000,000 fire-bricks annually manufactured in the north of England. Of this quantity 2,500,000 were consumed about the various works in the northern counties, 3,000,000 were sent to other parts of the United Kingdom, and 1,500,000 were exported. In 1862 it was calculated that over 80,000,000 fire-bricks were annually made in Durham and Northumberland, and the local consumption had risen to 43,000,000, so that within a quarter of a century the local consumption of fire-clay goods had increased about 1,700 per cent., while the home trade had increased upwards of 900 per cent., and the export trade upwards of 600 per cent.

Durham and Northumberland offered special facilities for the manufacture of fire-clay goods. There is, to begin with, an abundance of fire-clay, which is usually found beneath the coal measures, in layers varying in thickness from 12 in. to 5 ft. or 6 ft. The best descriptions of fire-clay always contain a large proportion of silica, and analyses made on clay obtained in the neighbourhood of Newcastle showed that the percentage of silica

varied from 47 to 83 per cent. Then, again, there is in the north of England a demand for fire-clay goods that is probably unequalled elsewhere. Durham and the North Riding of Yorkshire constitute the centre of the largest iron-producing district in the world. Fire-bricks are chiefly used in the manufacture and repairs of both blast and puddling furnaces. In Durham, also, there is an extraordinarily large demand for fire-bricks on account of the large number of coke-ovens in operation; while the same commodity is largely used in the making of retorts for the chemical works on the Tyne, in the construction of pit-shafts, and for other structural purposes more largely carried on within a few miles of Newcastle than in any other part of the kingdom.

We have said that Sir Joseph Cowen is entitled to rank as a pioneer of this important industry. The quality of his productions was so superior that they became celebrated, not in the north of England only, nor even in the United Kingdom, but throughout the whole civilized world. Wherever English-made goods are made use of, there Blaydon bricks are sure to be found, whether on the shores of the Atlantic or the Pacific, at the Antipodes, or in any part of Continental Europe. A Blaydon brick is not unfrequently the first thing that turns up to remind a voyager in distant lands of his native country. Since Sir Joseph Cowen took up the trade many others have gone into it, and it is even probable that some may have surpassed him in extent of production; but none have acquired such a cosmopolitan reputation as a fire-brick manufacturer.

Sir Joseph was the inventor of a very successful process for the manufacture of fire-clay gas retorts, the object of which was to make such clay retorts for generating purposes as would be capable of withstanding the effects of the various changes of temperature to which they require to be exposed, and consequently render them less liable to crack. To accomplish this result, he mixed with Newcastle or any other fire-clay, sawdust, pulverized wood, charcoal, coke, carbon obtained from the interior of gas retorts, and other carbonaceous materials, in such proportions as the character of the clay may require, thus rendering the clay partially porous, and obviating to a large extent its liability to crack by change of temperature. To manufacture gas retorts from these earthy materials the inventor made use of a peculiar kind of mould. In commencing the operation of moulding a clay retort by means of this apparatus, the interior of a single mould is uniformly worked over, by hand, with a substantial coating of the clay, which is then beaten down to any required uniform thickness, from about 2 in. to 4 in. When the first mould has been thus coated, and so much of the clay retort shaped and finished, a similar mould is placed upon the top of the former, their edges perfectly coinciding, and then they are bolted together. When this is done, the interior of the second mould is coated with clay, in like manner to the first, and thus the retort may be continued to any length by erecting one mould upon another, and carefully joining them. Sir Joseph, we may add, was one of the first to manufacture gas retorts from fire-clay, although retorts made of that material are now the rule rather than the exception.

Even before he had attained to the age of puberty, Sir Joseph Cowen manifested a warm interest in all movements of a political character, and he was a prominent member of the Northern Political Union, which did a great deal in the north to foster and promote the agitation that eventuated in the passing of the Reform Bill of 1832. He was also, we are told, one of the earliest members of the Anti-Corn Law League, and of the more recent associations formed for the purpose of giving effect to the Reform principles enunciated by the late Mr. Joseph Hume, Sir Joshua Walmsley, and others. In February, 1865, the advanced Liberal party in Newcastle presented a requisition, bearing 2,178 signatures, to Sir Joseph Cowen, inviting him to become a candidate for the representation of the borough in Parliament. He complied with the request, and in the July following he was returned at the head of the poll. At the general election in 1868, a contest again took place, and he also on that occasion headed the poll, having received 7,057 votes; his former colleague, Mr. Headlam, having 6,674, and the defeated candidate, Mr. C. F. Hamond, 2,727. The hon. member gave an independent support to the government of Lord Russell, and afterwards to that of Mr. Gladstone. He was one of the few members who went into the lobby with Mr. Miall in favour of the disestablishment of the Church, and he also voted for Mr. Peter Taylor's Game Law Abolition Bill. He sat below the gangway, and always voted with the Radical section of the party, although he gave a hearty support to all great Liberal measures of the government. During the session of 1873 the health of the hon. member was such as to prevent him giving so much attention as he desired to his parliamentary duties; but during the earlier sessions he was one of the most constant attenders in the House. He voted with the government in every division on the Reform Bill, and also on the Irish Church and Land Bills and other leading Liberal measures. During the negotiation of the Commercial Treaty with France, Sir Joseph was invited by the government, at the instance of Mr. Cobden, to accompany him and other gentlemen to Paris to settle the details of that measure. He was engaged in the negotiations with the French authorities for several months, and on their successful completion he received a medal and the formal thanks of the French and English governments for his services.

After a very short illness, Sir Joseph Cowen died at his residence, Stella Hall, Blaydon on Tyne, in the month of December last. He was succeeded in his parliamentary representation of Newcastle, as well as in his business, by his eldest son, Mr. Joseph Cowen, now the senior member for the "canny toon." In not a few essential characteristics the son is eminently representative of the sire. The same ardent thirst for political progress has been manifested by both, and both alike have displayed in all business relationships an energy, aptitude, and industry, applied so judiciously as to reap a rich harvest of success. It is due to the exhibition of these qualities by the son, that the "Newcastle Chronicle," of which he is the proprietor, has come to be spoken of as the "Times" of the north of England, and can claim, not unrighteously, the distinction of having the largest provincial circulation. But the lines of the eventful career of the present senior M.P. for Newcastle must be left to another pen to trace. With Sir Joseph Cowen we have done. His was a useful and beneficent life, an example and a pattern to succeeding generations; and he had the satisfaction—accorded, alas! to the minority only—of living long enough to see the full perfection of his life's work.

DIRECT PROCESSES.

By Charles M. Dupuy, C.E.

THE great wealth of magnetic ores in America is exceptional throughout the world. While they are of surpassing richness—almost pure iron—we work them into metal at a high cost for labour, and at a great waste of fuel and ore.

It is curious to note the slow development of any art, more particularly the manufacture of iron, surrounded as it is with so many real difficulties, and hedged about by so many firmly-rooted prejudices.

Iron ore is mainly a compound of oxygen gas, earthy matter, and metallic iron. Almost the whole theory of reduction of rich ores is to volatilize oxygen, for the earthy matter may be nearly all washed out before heat is applied. Oxygen is the arch-enemy. In well-washed magnetic ore, as usually prepared for the forge fires, nearly one-third, by weight, is oxygen, and the entire remaining two-thirds is metallic iron.

Carbon in its various forms is, *par excellence*, the reducing agent. At the required heat, the oxygen in the ore, having a greater affinity for the carbon, leaves the ore, and passes off as carbonic oxide. The most perfect system of reduction consists in bringing ore, carbon, and heat together, in the most exact and economical proportions.

The earliest process, practised by the ancients, and still largely in use to this day, is the forge-fire, Catalan forge, or bloomery in its various forms. Here, rich ore mingled with charcoal, is subjected to a blast in a furnace, resembling a large blacksmith's forge, until reduction is effected. On the theory that oxygen will leave the ore when heated, and unite with carbon, the forge-fire method at first glance would seem to be a perfect process. This, however, is not the case. While reduction is in progress, and until the last atom of oxygen has left the ore, it is always ready to seize with avidity any "free oxygen" it may find in the blast, or draw from the surrounding atmosphere. It is this "free oxygen" which so largely consumes the fuel, and is the means of melting down a large proportion of ore to a useless cinder. It causes a consumption of 300 to 500 bushels of charcoal, and over two tons of washed or separated magnetic ore to the ton of iron, whereas, less than 100 bushels of the former, and less than a ton and a half of the latter, would be quite sufficient, could these objectionable features be removed. Another objectionable feature to the forge-fire is want of uniformity of product. That part of the bloom formed nearest the blast is semi-steel, while that farthest away is soft iron.

Frederick Overman, in his little work on steel, says we want purer iron. "The immense ore beds of New York, New Jersey, Missouri, and Wisconsin, as well as of other states, are unsur-

passed in purity, and should produce iron equal to the best Swedish, and at a much cheaper rate than it can be imported. Ours are peculiar conditions, and resemble those of no other peolpe. We should not copy the processes of other nations, but work out our own method in our own way."

The immense deposits of rich cinder from the forge fires which had been accumulating in England since the conquest by the Romans, finally suggested the invention of the blast-furnace to work them up. It was soon found useful to smelt the lean ores, which abound so largely throughout Europe, and although the invention dates back three hundred years with comparatively few improvements, the blast-furnace still continues the great right hand of the iron-master.

The facility of melting down large quantities of crude material, so as to separate the metal from its grosser impurities, in large and continuous operations, was certainly a great step to keep pace with the rapidly increasing wants of an iron age. Still, while the blast-furnace frees the metal from its oxygen, and separates by specific gravity a large portion of its earthy impurity, it is by no means a perfect instrument for the manufacture of superior wrought-iron. Owing to the variation in the atmosphere, and other uncontrollable causes, the run of a blast-furnace, from day to day, not unfrequently is wanting in uniformity, and, besides, is always charged and intimately incorporated with four to five per cent. of carbon. This carbon clings more tenaciously to the iron than the oxygen did to the ore, for the ore parted with its oxygen at a red heat, but pig-metal must a second time be melted, and skilfully manipulated for nearly two hours before it gives up its carbon. It is true that the second melting, although involving high cost for fuel, labour, and waste, separates quite perfectly the earthy impurities which may have remained; yet the fact that the forge-fire can exist, and that its product is so largely in demand at a much higher price, and for purposes that puddled iron cannot supply, is conclusive proof that blast-furnaces do not fill up the need for a certain high quality of metal, which can only be produced by a direct method. The truth probably is, the blast-furnace is best adapted to working the lean, while the better direct method should be adopted for the rich ores.

The vast deposits of rich ores, yielding from 60 to 70 per cent. metallic iron, have long demanded a better system of reduction. During the past half century various expedients have been suggested. One proposed to subject ore with carbon to heat in clay crucibles, until reduction takes place, then to empty and hammer the product, but it was found the iron adhered to and became incorporated with the crucible, causing waste of the former and destruction of the latter. Another suggested ore with carbon, heated in gas retorts. Gas retorts were tried, but were too perishable to be found useful. Another proposed heated vertical tubes, or retorts of fire-bricks; these, like the gas-retorts, were too soon destroyed by a deoxidizing heat to be practical. Still another aimed to deoxidize ore with carbon, on fire-brick tables, which were heated above and below. The sensitiveness of the ore to the absorption of oxygen found floating in the furnace failed to secure a perfect deoxidization, and this plan was rejected. All these, and many other processes, although at times producing iron of superior quality, were not found economical. They have had their day of experiment and abandonment, and still a better direct method than the forge-fire is demanded.

The ore seems to require a continuous reducing heat, from the time it is placed with carbon for deoxidization until it is reduced and consolidated to iron. Carbon will not act efficiently in withdrawing oxygen from the ore, if it can find "free oxygen" in the furnace. Such is the affinity of ore for oxygen, that however well the deoxidizing process may be progressing, if at any stage, until it is completed, the heat is changed from a "reducing" to an "oxidizing" heat, success is measurably defeated, and waste the result.

The whole aim should be to continue a reducing heat in the furnace until the ore shall be thoroughly penetrated through by it, at the same time to shield both ore and carbon by a suitable covering from any free oxygen, until it is not only reduced, but consolidated to metal. Whatever earthy impurity may remain in the ore after cleansing, and before the application of heat, is readily removed by the high heat required to weld the particles of reduced metal together. At this heat the earthy impurity is liquefied, and is compressed from the porous mass of iron, under the hammer, as water is squeezed from a sponge.

The elder Mushet—the father of iron experimentalists—observed the wastefulness of its manufacture, both in the forge fire and blast furnace, and spent his long and useful life in the improvement of iron. Among various other experiments, as early as 1794, he mingled ore and carbon in a crucible, and subjected it to a heat which reduced the ore and welded its particles together. At the same heat, after breaking the crucible, he was delighted to be able to hammer its contents into a solid bar of iron. Here was the real starting point of all the direct processes. The containing vessels, retorts, chambers, or crucibles of various shapes and sizes, which since that time have been the subject of so many costly experiments and disappointments, must necessarily be of considerable thickness, to withstand, for a single operation, a heat sufficient to penetrate from the outside the few inches in thickness of ore and carbon lying dormant within them. A heat energetic enough to produce a thorough deoxidation in a reasonable time, practically, is too destructive and costly of crucibles to be made profitable. To prevent this damage, a moderate temperature, reaching over a longer period, has been tested, but a moderate heat only partially deoxidizes the ore: it requires a high temperature to accomplish deoxidation thoroughly, and with sufficient energy. Beside this, the newly made metal is left in a porous, spongy condition, and is peculiarly sensitive to the furnace gases. It will receive a varnish of fresh oxygen over the innumerable little surfaces of its cells, or pores, or fibres, not only while exposed in that condition in the furnace, but still more the moment it is cooled and penetrated by the pressure of the atmosphere, just as every bar of iron, after cooling, receives a scale of oxygen on its surface.

To prevent this attack of the atmosphere, the hot, spongy iron, without external exposure, was at once dropped into the balling or reverberatory furnace. Still the waste proved excessive. This may be satisfactorily explained. While a portion of the oxygen, thrown into the furnace, unites with the carbon to supply a welding heat, another portion penetrates to the infinitesimal surfaces of the pores or fibres of spongy metal, and these combined surfaces, so oxidized, are of such large extent as to cause great waste.

The aim, then, was to close these pores, so as to prevent the penetration of the furnace gases, by pressing the cooled sponge into blooms with hydraulic power, previous to the second heat. If the ore could have been thoroughly deoxidized at first, by the application of sufficient heat around the crucible, and if the surfaces of the pores had not been varnished with oxygen, on exposure to the atmosphere, as explained, this step might have been successful, but the small yield and rich cinder still pointed to a defect.

We may pass by all that class of processes for working ores to metal at one operation, on a series of tables or shelves, in a reverberatory furnace. The most prominent of this class is Harvey's process, on which large sums were fruitlessly expended for a number of years. They have not been successful because the oxygen of the furnace is quite as ready to penetrate the cells of the partially reduced and exposed ore as it is to unite with carbon to support combustion. For a like reason all furnaces, either rotating or fixed, with the flame passing through them, and coming in contact with the ore, cannot be the most effective.

For a time there was a process which was thought to promise success, because the deleterious furnace gases were excluded throughout the operation. The ore was packed with carbon in alternate layers in a steel converting furnace, to the extent of 40 to 50 tons, and gradually heated from the outside up to the welding point. In a couple of weeks the metal, thoroughly reduced and consolidated, was removed in a cool state to the balling furnace. The maintenance of this converting furnace up to a high heat for repeated operations would of itself have defeated this process, had there not been a more serious difficulty. The ore, it is true, was thoroughly reduced, but was more or less carbonized, up to the condition of cast-iron, but the process was too expensive, for the manufacture of pig-iron it could never have successfully rivalled the blast-furnace.

In following out these various devices, they were thought to be fairly based for success on the exact results from covered crucible in the laboratory, and in keeping with the blast-furnace and forge-fire operations. In the laboratory, the heat applied outside of the closed crucible brings all the metal either to cast or wrought-iron, at pleasure, by properly proportioning the carbon, because no external oxygen can interfere. Deep down, and between the thick walls of the blast-furnace crucible, in like manner all atmosphere is excluded, and the large excess of carbon it contains thoroughly decomposes the oxygen of the blast. In it the high heat required for perfect deoxidization is maintained, and the metal, saturated to a high degree with carbon by the powerful blast pressure, is nearly all saved as a carburet or pig iron. The shallow forge-fire, with a light blast, certainly produces wrought-iron in a few hours, but with great waste of fuel and ore, which is accounted for by the penetration of the atmosphere.

Experience proves that it is clearly impossible to impart sufficient heat from the outside of a chamber or crucible to accomplish practically, on a large working scale, the results reached by laboratory experiments in the chemist's crucible. Nor can a high

column of ore be uniformly penetrated by a blast of reducing gases forced through the mass. As in the German "Stuck" or "Wulf's" oven, the blast pressure necessary to penetrate to the top a high column of ore, at every operation, will produce a mixture of cast-iron, steel, and wrought iron, of grades varying from the base upward. A low column of ore will have the atmospheric objections of the forge-fire. It is, further, impossible to maintain a welding heat in the ordinary reverberatory furnace without having the delicate fibres of partially reduced ore largely destroyed by the deleterious gases to which they will be more or less exposed.

To ensure an economical, direct method, the operation must not pause with the production of spongy iron. As in the chemist's closed crucible, or in the blast-furnace or forge-fire, the process must go on with a continuously increasing heat, until the cells and fibres, produced by the withdrawal of oxygen from the ore, are compressed together and solidified into a cake, at the pasty condition of the metal. It is then a commercial product of wrought iron, either hammered or otherwise.

How shall this be accomplished? Some years since the writer suggested that rich ores, mingled with the proper proportion of carbon for reduction, should be placed in thin sheet-iron cases, of size most convenient to handle. Many of these canisters of ore, to the extent of several tons, placed in a simple cheap furnace, of a peculiar device, in a few hours will become caked and solidified to wrought iron without further labour, while the encasement will be preserved to the end, the whole to be hammered into a bloom or bar at the same heat.

Deoxidization commences immediately on the introduction of the canister into the furnace, as proved by the blazing of carbonic oxide from them, which continues without intermission until reduction is completed. The heat, which is gradually absorbed, increases in intensity until reduction is effected, and the particles of iron are pasted or matted together; then canister and contents being withdrawn, are welded together by any of the ways puddle ball is usually treated.

The sheet-iron canister or crucible will cost from 20*s.* to 25*s.* to the ton of iron produced. It is a convenient, portable package, keeping the particles of ore in close contact with the exact proportion of carbon required for reduction. It allows the heat to penetrate readily on all sides. It is homogeneous with the new metal, and welds up with it under the hammer. Above all, as it shields and protects the ore from the blast and furnace gases during the whole operation of deoxidization and consolidation, the metal is of superior quality, and is nearly all saved. A series of experiments, extending over many years, confirms the writer in the belief that this process solves the problem of the manufacture of wrought-iron direct from the natural oxides, on any scale of magnitude, and at a cost, both for plant and manufacture, which will effect a great saving over the indirect method. The results of these experiments, in the form of samples of metal taken at all stages of the process, are open to the inspection of any one interested in this subject.

A RECORD OF EXPERIMENTS, SHOWING THE CHARACTER AND POSITION OF NEUTRAL AXES, AS SEEN BY POLARIZED LIGHT.[1]

By Louis Nickerson, C.E.

Preliminary.

THE experiments recorded in the following pages, were undertaken with a view to discover, whether the law of the "lamination of material in planes perpendicular to the direction of the pressure exerted upon it," was a law incidental to a periodic[2] action of force, as pressure; or only consequent upon tangential stress, faults in the cohesion of material, or the running together of internal cells. The first of these was made by sending polarized light through plates of glass, compressed so as to be bi-refractive either in the character of beams or columns bearing weights.

As some exception may be taken to this apparently absurd means of obtaining the course of strains in materials used in construction, and because glass is itself a useless material for the sustaining of weights, it may be well that the experimenter's reasons for the proceeding should be given. The difference in effect between like action on two materials is not absolute, but only relative, therefore the effect of the action of force in glass must be similar to its effect upon other substances, excepting for amounts and confined qualities. One of these latter is transparency, but this becomes useful; and moreover, as the particular results which we wish to arrive at are derivable from certain general laws of the "doctrine of forces;" which must be precisely the same for all substances and only modified not changed by any particular substance, and which the transparency of glass and its bi-refractive quality when strained enables us to watch with the eye of the body, in assistance to the eye of the mind; we may, in this partial case, completely ignore structural differences. So that, having become satisfied in regard to the general law, we may be better able to systematically admit the modifications. These modifications, indeed, would not appear to be very great. Glass, cast-iron and steel are all amorphous bodies, yet all composed of segregated crystals, and during the experiments a connection was established in the characteristic form of breakage; all as a general result appearing to yield in this form: when the fracture occurs

Fig. 1.

Fig. 2.

in a beam between a supporting point and a point of pressure, and in this one when the fracture occurs immediately at a point of pressure: it being readily noticed that the law of fracture is the same in both cases; fig. 2 being similar to fig. 1, with an opposite duplicature. Another and very important link of connection is believed by the writer to exist in the relative ratio of their respective resistances to tensile and compressive strains, as there is good reason to think that in this respect glass occupies a place between steel and cast-iron. These facts, however, become of less importance as we begin in the experiments to perceive the action of general laws, and to refer to their effects without regarding the vehicle which transmits them.

The form of apparatus used was the common one for experiments with polarized light, made without the microscope; namely, a bundle of glass plates—parts of window panes in this instance—6 by 8 inches. This was the polarizer, and one plate of heavy glass of the same size, blackened upon its back so as to reflect from only one surface, was the analyzer. The first is set at an angle of 33° from the window through which the light is obtained, and the latter at an angle of 33° from the table upon which it is placed, or rather it is so placed that the rays of light reflected to it from the polarizer, come to the eye of the observer placed above at an angle of 57°. Between the polarizer and analyzer is held a small brass clamp used for compressing the object under examination. Looking into the analyzer, there is seen before compression, the clamp (a square frame of brass, with a thumb-screw moving from the top side towards the bottom) containing, in position, according to the experiment intended, a slip of glass, or a piece of glass tube or rod.

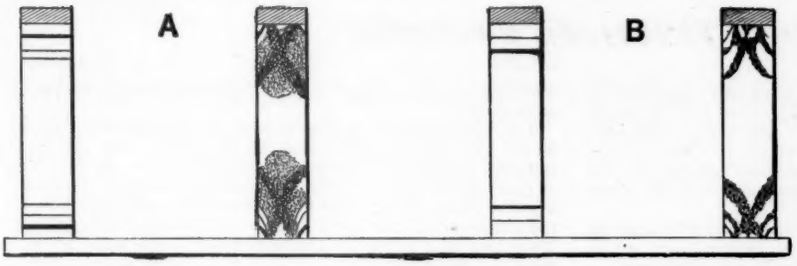
The glass appears clear and ordinary looking, because of the ordinary light which is present, but if our apparatus were so closed up on all sides as only to admit of the polarized rays, *it would appear black, for in a neutral or unstrained state, it is not permeable by those rays.* Yet even now, by close examination, we perceive a cloudiness.

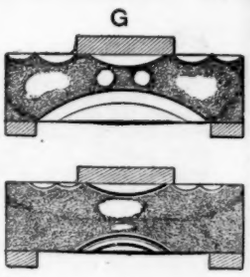
Beams.

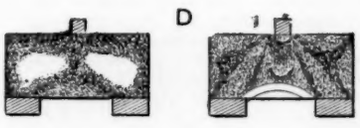
Supposing that our object is a beam, as *G* (see Plate), and we tighten the screw a little, immediately we obtain clear spaces with curved outlines at the top and bottom of the slip, while the darkness of the middle portion seems to increase. This dark space, in all its changes of form, marks by its outlines the neutral or unstrained sections of the beam. As it at first covered the unstrained beam, so it ever, by well-known optical laws, covers those portions of the beam remaining neutral or unstrained. Its increasing darkness, even, is only the effects of optical contrast; to pure polarized light it has always been black. Yet it does become more and more defined and distinct and narrower, as with the increasing pressure its outline becomes sharper. Soon, from the top and bottom of our beam, coloured curves, each sharply distinct from the other, and having for their outlines the mathematical lines of strain, begin to make their appearance. As the pressure is more and more applied, they increase in number and brilliancy, moving always towards the neutral space. To a certain extent, there is a change of form, but the general curve is sustained until the period of fracture renders the image but a void of broken glass, the fractures of which may now be examined to obtain their position and character.

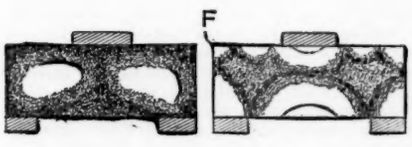
[1] Trans. Am. Soc. Civil Engineers.

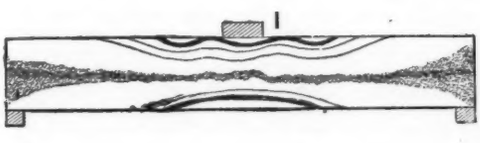
[2] The word "periodicity" being used to express a reoccurring phenomenon without reference to the time occupied.

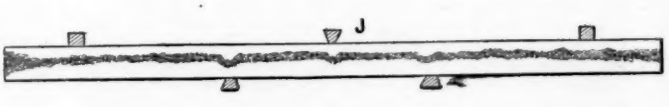


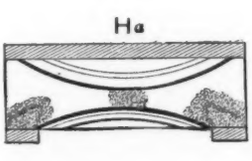


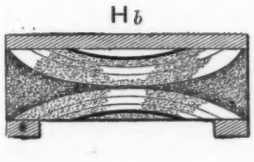


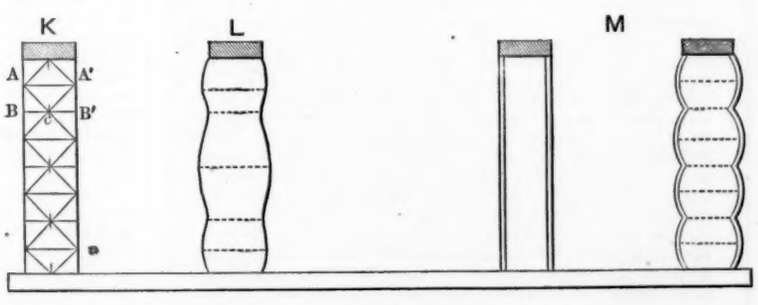


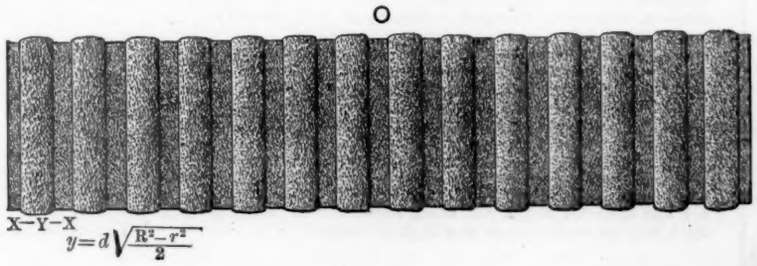












XUM

The images of *G* give a good idea of the results appearing in a beam, the ratio of whose depth to length is as 1 to 3·5, which rests upon two points of support, and which is pressed by a force partially local and partially distributed. The pictures opposite each other in the right and left-hand columns, are the positive and negative images of the same object in the same state.

The relative causes and properties of the positive and negative images, which together form each double picture, cannot easily be discussed until we have acquired, later in our experiments, a better knowledge of the character of the phenomena, after which, their great co-operative value will, doubtless, be admitted. They are, as arranged, images of the same state of the same object taken, first in one position, and then in another in the same plane, 45° distant, or by a revolution of the analyzer at each 90° distance. The words *positive* and *negative* are, of course, purely arbitrary, the negative image being the one occurring when the beam is horizontal and the column vertical.

The first matter which engaged attention and gave a definite course to the experiments, was the unsuspected and peculiar form and character of the neutral axis, and systematic trials were shortly commenced to arrive at a full understanding of its status, under all circumstances of load and position. It will be remembered by engineers, that during the long, patient and able researches of Eaton Hodgkinson, F.R.S., published in 1842, he took the ground that the neutral axis was shifted by increasing the weights used, and, ultimately, that its position should be found at a line which would equalize the sum of the stretching and shortening forces, by a corresponding distribution of material above and below it. He fixed this line for cast-iron—at the period of rupture—one-seventh the depth of the beam from the top, because the resistance to compression of that material was seven times as much as the resistance to tension. He occasionally found rectangular beams, which broke, so that the broken edges exhibited a crushing force of one-seventh of their depth, while the tearing forces occupied the other six-sevenths, thus apparently corroborating his theory by an exact distribution of strains, in accordance with his previous experiments upon the compressive and tensile resistances of the material. Therefore, and most naturally, too, his whole argument makes it clear that he looked upon the neutral axis of the unloaded rectangular beam as a line at first coinciding with the longitudinal axis, but which gradually rises towards the concave side at each accession of weight.

In 1855 Henry Barlow, F.R.S., made experiments on cast-iron beams, purely to test this theory of Mr. Hodgkinson.[1] In the course of these experiments Mr. Barlow decides, in direct contradiction to the views of Mr. Hodgkinson, that the neutral axis in a rectangular beam under all circumstances lays through the centre of gravity of the beam sections, and that there is a third element of strength consisting of the lateral adhesion of the fibres—"something like friction"—which increases with the curvature of deflection.

Both experimenters start from the same point, viz :—that the transverse strength of a cast-iron beam is about 2·5 times as great as it would be to accord with experiments on its tensile and compressive strengths, and each records a different theory from the other in regard to the character and position of the neutral axis. This paper will show, that while both gentlemen were correct in the experiments made by them, these experiments were so diverse in character as to lead to two opposite theories by necessity, and by making a connection between the two sets of trials, also connect the observed phenomena and correct the theories. An attempt will be made to establish that the neutral axis is a flexible line, truly parallel to the top and bottom sides of the rectangular beam, and passing through the centres of gravity of its sections, only when the load is evenly distributed from end to end, or when the beam should be infinitely long ; but that when there is a local pressure the neutral axis is more or less governed in its direction and form by the strain passing from the point of local pressure towards the points of support.

This mobile character of the neutral axis having been observed by the writer in his earlier trials, his first object when systematizing the further experiments was to obtain a law of direction, or rather to examine one already prevised. For this reason the negative image of column *A* was taken and recorded as evidently the simplest case that could be provided of direct compression. Then two slips of glass, *C*, were fastened in the press, so that when the pressure became heavy the two outside bottom corners should press against practically inflexible buttresses—the inside top corners press against each other—and the inside bottom corners and outside top corners of course be free. Thus there would be no tension in the beam, as a beam, and the compression could be governed by the screw until the coerced corners should be ground to powder. The image plainly represents two inclined columns like *A* each, or to speak more technically, two "struts."

The simplest and most efficient way to conduct the experiment was obviously to make its different steps as closely consecutive as possible. The next object, therefore, should be to obtain a very small tensile strain with a great preponderance of compression. *D*, which was the next subject of trial, was a very short slip in proportion to its depth, with points of support very close together, so as to allow of but little flexure, and pressed like the rest by the small leather guard of the screw. Passing across from the negative to the positive images for reasons to be hereafter given, a dark line surrounding a blue figure may be observed in *D*, as in the positive of *C*. Now, this blue figure is the complementary or positive appearance of the struts of negative *C* and *D*, and the dark surrounding line must, from the law mentioned in the first part of this paper, be neutral. In fact, the blue is in a state of semi-neutrality, shown by the small amount of the polarized light passed through it.

Confining the discussion to the neutral axis as it appears in the subsequent positive images, until experience shall have taught us the co-operative uses of both, let the beam which rests upon inclined but partially flexible supports be gradually lengthened in *E*. The blue is now less characteristically a strut, but the dark line still surrounds it. Only, however, on the side towards the middle of the beam is it plainly marked, and then not more so than in the new portion, which forms a curve extending from one corner of the "pressure-block" to the other. The neutrality in this case, then, is in the narrow band running from one abutment in a curved line to the corner of the pressure block, from thence in a curve to the other corner of the same block, and from thence in a third curved line to the other abutment, and in two branches proceeding from the abutments toward the upper corners of the beam ; the space between the first and third and the branches remaining, as it were semi-neutral. Looking backwards it will be perceived that the first and third lines, the branches and the semi-neutral spaces result from the strut strains, formed by the direct compression from the pressure block towards the abutments, and we may begin to believe that the second line has been formed by the introduction of a distinct tensile strain along the lower part of the beam, creating with a horizontal compressive stress the bending moment which is just breaking in to complicate the strains. Simultaneously with this bending moment it will be perceived that coloured curves appear upon the top and bottom of the beam. This beam, however, is far advanced towards the point of rupture.

F is a longer slip in proportion to its depth, but the local pressure is still upon its centre. In this, the general neutral space is a broken curve or arch, from one abutment to another, only sending off cloudy branches, towards the upper corners of the beam, and the lower corners of the pressure block. This slip has, as yet, been little pressed, and the yellow colour of the curves shows that they have but recently made their appearance. In *G* is shown the image of a beam upon the border of breakage, generally similar in character to *F*, but the beam being longer in proportion to its depth, the arch becomes much flattened ; we still observe the running up of the neutral space towards the same points, and further notice that they inclose the coloured curves in so doing, like the quiescent water which lies between opposite vortices.

H a, H b, is a beam with the load equally distributed. The "strut force" has disappeared from the top, and is only marked upon the beam, where, starting from the abutments, it becomes diffused about the centre, spreading, as might have been expected, when a local strain was changed to a general one, throughout the whole top of the beam. Undirected by a local pressure, it becomes undefined and cloudy, the neutral space belonging to the regular bending movement of the beam, detaching itself and becoming a horizontal line for the first time. The coloured curves are regular and nearly equal on top and

[1] He says:—"It has long been known that under the existing theory of beams, which only recognises two elements of strength, namely, the resistance to direct compression and extension, the strength of a bar of cast-iron, subjected to transverse strains, cannot be reconciled with the results obtained from experiments on direct tension, if the neutral axis is in the centre of the beam. The experiments made both on the transverse and the direct tensile strength of the material have been so numerous and so carefully conducted as to admit of their accuracy, and it results from these, either that the neutral axis must be at or above the top of the beam, or there must be some other cause for the strength exhibited by the beam when subjected to transverse pressure.

"In entering upon this question, it became necessary to establish clearly the position of the neutral axis, and the following experiments were commenced with that object, but they have led to others, which are also described herein, and which established the existence of a third, very important element of strength in beams."

bottom, and with the exception of the "strut force" which appears in the negative at the abutments, and the complementary shading in the positive, there is no sign of local pressure. It may be noticed, too, how its coloured curves are becoming more nearly similar in positive and negative images—how the colours are becoming more plainly complementary in the two images and how an umbra, which is a true neutral axis, surrounds the coloured curves of the negative and connects them across the centre. Looking back, we may now perceive this neutral axis, in direction nearly perpendicular to the one in the positive image, has followed us up from the column to this point, and will beyond.

I is a long beam in the ratio of its depth, and we see clearly how its length, or rather its flexibility, draws the neutral axis out into a nearly straight direction, parallel with the top and bottom edges; yet leaving perforce a slight upward tendency in the middle of its length due to the local force.

J is different in character from all the foregoing, and in attempt, represents a railroad bar pressed upon at one point, resting upon two cross ties, and prevented from rising by others, to which it is supposed to be spiked. Again the self-same laws prevail, the neutral space, in general horizontal, tends to bend itself toward each pressing point, and as in all the other images to brush out when free.

Those beams of Mr. Hodgkinson's by his own account, which plainly showed the neutral axis as being above the centre of gravity of the transverse sections of his beams, were *broken at the centre by a blow.* It was, therefore, as these drawings show, the local force and not the ratio of compressive and tensile resistances which governed its position. Mr. Barlow experimented with long beams, twice as long in proportion to the depth as any of those which appear here, and nearly 1·5 times as long as those mentioned by Mr. Hodgkinson in this connection. As the increase of the "bending movement," and the decrease of the "strut strain" keep pace with this lengthening of the beam in the ratio of its depth, he naturally found the neutral axis more nearly horizontal and less distorted than even in *I*. Beams of glass, with a ratio of 1 to 14, which is the proportion of those used by Mr. Barlow, show a very faint distortion from the horizontal and measuring as he did from points one foot distant from each other, this slight distortion might easily have escaped the scrutiny of his micrometer. Indeed it must be almost indefinite in beams having a ratio of more than 1 to 10.

May not it then be said of the neutrality as it appears by polarized light, that it is not a mere line in the mathematical sense of the word, but by reason of the cohesion of material or other cause, is extended to a breadth, and can never become a true line until the tensile and compressive forces become in relation to the cohesion—infinite; or, in other words, that although the neutrality of "stress" is a mathematical line, yet as in material it must require a certain definite "stress" to produce a "strain," the initial "strain," namely, that sufficient to overcome cohesion, must be at some distance from the mathematical line of neutrality. Beyond this it appears that its longitudinal direction, like the directions of lines of strain, is not an arbitrary one, but is resultant from the relative qualities and quantities of all the forces in the beam, its evident place in physics being precisely that of the still water between opposing eddies or vortices.[1]

Positive and Negative Images.

It will be noticed that as yet no cause has been discussed for the difference between the right and left-hand views in the plate—the positive and negative images. To understand these, it is necessary to know, generally, that polarized light differs from ordinary light, insomuch that instead of vibrating from a centre outward in all directions in the same transverse plane, the pulsations are confined to two directions which, when a completely polarized state is effected, are at right angles to each other. In this condition the pulsations in one direction are transmitted through certain substances, when the beam of light strikes them at particular angles, while the pulsations in the other are reflected, and *vice versa.* Secondly; if ordinary light, or either of these beams, are transmitted through a bi-refractive substance, there will be a division into two other beams at right angles to each other, and these falling upon an analyzing medium, properly arranged, will be either transmitted or reflected, according to the angle of their pulsations, so that the eye will be only able to discern the one reflected or the one transmitted. Thus the ordinary light coming through the window was polarized by falling upon the polarizer at an angle of 57°, one beam was transmitted, and, so far as we were concerned, wasted. The other reflected was made to pass through the object which, impervious to it in an unstrained state, became pervious and bi-refractive in a strained state, again dividing the one beam into two, at right angles to each other; the one of which is reflected to the eye from the surface of the analyzer, and the other transmitted through its face, but absorbed by the blackened back, until a revolution in part of the object changes the directions of pulsation and reverses the condition of the two rays.

When experiments were being made upon the first tubular bridges, it was found that a wave of "buckling" always followed an angle of 45°, from the top where the load was placed toward the bottom; even crossing the stiffners put in to retain this normal angle. This was similar in principle to what is here called a "strut strain." Evidently this would be impossible in equilibrium, unless there also existed a corresponding tensile strain at right angles. A resultant of these stresses in a beam would obviously be vertical. Again, it is known that the principal stress in an ordinary beam is the horizontal stress, composed of a compression in the top and a tension in the bottom, and that the resultant of these is parallel to them and is called generally the neutral axis. There are, therefore, two resultants at right angles to each other.

In the first section it was shown that the true neutral axis of a beam was not necessarily the horizontal line, usually so called, but a line resultant from the actions of both the horizontal and strut stresses, which was derived from the fact that the neutral or unstrained part of the beam coincided with this form. In a beam loaded with a distributive load, or one which is very long in proportion to its depth, the strut stresses assume angles of 45°, as before shown in the case of the tubular bridges, become individually small in comparison with the horizontal or flange stresses, and the horizontal stresses govern the resultant almost entirely, but as the beam is shortened, so that the strut or web stresses between the load and abutments obtain an ascendency over the flange stresses, then the strut stress interferes controllingly with the horizontal stress, and changes the direction of the resultant axis until in a column it becomes entirely vertical.

By a re-examination of the drawings it will appear that when the strut strains are in an ascendency over the horizontal strains, the negative images are by far the brightest, and although they afterward become duller—as the strut strains become relatively less—yet the preponderance of vertical stress is always evident in them. On the other hand, the instant a tensile stress was introduced, so as to oppose the compression or strut stress, and resolve the effect into horizontal or "flange" stress, the positive images became brighter, and continued so to grow *cæteris paribus* with the increase of the beam in length, and consequent relative increase of tensile and flange strains. Further, it should be remembered, that divers stresses may exist in the same piece of material, crossing each other, and probably being mutually neutralized at the crossing, but continuing on afterward as individual and intact as when first they met.

As the glass is pervious to polarized light, when strained, and impervious when unstrained, we can only regard the light parts as strained in proportion to their brightness, and the dark portions as unstrained or neutral; and as the strain is the cause of the bi-refraction, it follows that the latter must be governed by the laws which govern the former. Further, the resultant angles of the strains are rectangles, as are the angles of polarization, and as the strains change in character, so do the polar images change in correspondence. It follows, then, that the images are pictures of the strains.

But this may be examined in another manner. If all the light—except that which falls upon the polarizer—were dispensed with, the object seen by the eye without the intervention of the analyzer, would yield no appearance of colour, but only white light. Now, all the stresses in a *beam*, when united, must be in equilibrium, hence the light which measures and was produced by them, should also be in equilibrium, or in other words, colourless when the two rays are united. From this is deduced that the positive and negative images are complementary in form and colour.

Further, it may be fairly assumed, should these reasonings be correct, that if there is any one point in the object which is under no strain, whatsoever stresses be applied to the beam, that point must remain dark under all revolutions of the object or analyzer. Now, there is such a point in the centre of the beam, nearly in the middle of the primary neutral axis, and between the forks of the strut strains, and which, by laws already discussed, resolves itself into a space, and this dark space is always observable in the analyzer, forming a sort of nucleus, from which the changes from

[1] The neutral character of the dark bands is most plainly shown by working at an open window, where a large quantity of ordinary light is reflected from the polarizer. The neutral portions are pervious to ordinary light; and by this means a white speck set upon the polarizer may be made to pass across them, by a motion of the head, from one set of curves to the other, as a star passes across a clear belt of sky from cloud to cloud.

positive to negative and the reverse take place during the revolutions. It is obvious that this point marks the crossing of the resultant axes, the one formed by the "web" or strut strains, the other by the "flange" or horizontal strains, as before discussed.[1]

Coloured Curves and Secondary Neutral Axes.

The appearance of the light around the neutral band is the first symptom of distortion in the positive image, but soon there appears upon the top and bottom edges faint segments of yellow. At the lower side this occupies a large portion of the distance between the points of support, but at the top it varies with the arrangement of the load, the chord to the segment having nearly the length of that part of the beam directly pressed by the load. If the load be uniformly distributed over the whole length of the beam, the segment is similar at top and bottom, but if this be local, say consisting of a block of hard sole leather as a guard to the screw, then the segment will have about the same length as the block, and two smaller segments, differing a little in form, will appear at the sides. Beyond these again bright curves appear, as though preparing for the formation of more coloured segments; but the writer has never succeeded in bringing out more than three, with sufficient distinctness in the colours of the extra ones to be satisfied as to their character. It may not be amiss to remark here, that all the images and colours appearing were quite as distinct as the shades represented in the drawings.

As the pressure is increased, the yellow from both edges moves forward toward the neutral band, becoming soon a zone, and a segment of red succeeds. Both these continue to move forward with the increase until the red, too, becomes a zone and a segment of blue appears. This is the end of the first series, and we mark with interest that with the blue or between that and the red there came a dark mysterious line. Turning the screw continuously we force the yellow, red and blue to move forward, the blue becoming a zone, and bearing its dark line with it, which constantly grows darker, and yellow, red and blue again chase each other upon the field to form a second series. The second blue also has its dark line. So far I have found no glass to stand more pressure than this.

Let us now remember Mr. Barlow's words: "But they have led to others (experiments) which are also described herein, and which establish the existence of a third and very important element of strength in beams."

In loading a beam, it is probable that the pressing force first seeks to connect itself with, or as it were feels for, the points of support; afterwards the bending action commences. Now, suppose the load to be very small at first, and gradually to increase, there must be a time—for the new resistance can only exist, according to Mr. Barlow's experiments, after the beam is bent somewhat—when this resistance is only just equal to that portion of the moment of the compressive force (we are discussing, for simplicity, the top part of the beam), which is directly opposed to it, and which may therefore be called the bending stress. Taking the vertical section through the middle of the beam for the discussion, we may fairly suppose that this occurs just when the dark line between the first blue and red comes upon the glass. Mr. Barlow has shown that the new resistance or resistances increase as the beam is bent, but as we know that by the increase of load the beam is still further bent, we derive that the bending force increases faster. Therefore, if at first the bending resistance, multiplied by its minimum statical arm, was equal to the bending stress, multiplied by the distance from the neutral axis to the top of the beam as its maximum statical arm, which at equilibrium it must have been, it must at last be equal to the increased bending stress, multiplied by a shorter arm, itself being now multiplied by an increased length of arm, whose axis is at the top of the beam. The line of equal moment then between these two forces must have moved down in the interim nearer to the primary neutral axis, and must continue to move downwards toward this axis as the load is increased. This is exactly the action of the dark line in the blue, and its appearance, to one frequently engaged in examinations by polarized light, is that of a line of equal antagonistic forces—in other words, a neutral line.

In a first examination of this matter there seems to be something anomalous in the fact of a neutral axis existing amid distorting forces, of a line in the top part of a beam which is neutral, yet growing shorter, or in the bottom part and retain its neutrality while increasing in length. But it is not so; for if we should load a beam to bending, and then without changing the relative status of its flange strains, compress or stretch it bodily in length, we should have precisely the same phenomenon—a line which is a neutral line between two forces—yet increasing or decreasing in length by the operation of other forces acting independently of the first. There might be a modification of form besides the change in length, but there could be no cause for annihilation.

Further notice of the movement of this secondary neutral line (if we may call it so), toward the primary neutral line suggests that should the two come together, then, according to our former reasoning, the bending stress, multiplied by its smallest statical arm, would have become just equal to the bending resistance, multiplied by its longest possible statical arm (from the top of the beam to the neutral axis), and that any additional increase of the bending stress, however small, would bend the beam infinitely, because totally unopposed; or in other words, the beam would break. This reasoning was curiously confirmed in the following manner: while watching the consecutive phenomena occurring in several slips, set one upon another, thus forming a laminated beam, with a small hand microscope, all the slips, save one, suddenly broke. For some reason, perhaps from the elasticity of the broken glass, or perhaps the screw which had been shortened by the reaction of all the slips, began to recover its length when only resisted by one, the secondary axis continued to move forward, so that the observer, not having the screw to manage, could watch its movements at leisure. As it neared the primary axis, its curve began to take the form of a bow, the two quarters passing the middle in the direction of motion, and when very close, two loops were prominently advanced, first one and then the other. As the first touched the primary axis, a sharp "click" was heard, and fine fragments of glass flew like hail from the sudden rupture, which followed just at *that point*. Immediately the second loop touched, with precisely the same phenomena, when the vision was gone and only fragments of glass remained. It is to be regretted that the flying of the glass particles made it impossible to watch the movements of the secondary axis in the lower part of the beam, or either of the dark lines in the second blue, but closer preparation at another time, when the phenomena is looked for, may lead to interesting results.

Columns.

The column appeared to us at first as incidental, taking a subordinate place in discussing the general laws of a compressed beam. We shall now see that its own phenomena are well worthy of deep study—that it resists pressure by strange geometric laws, and marshals its forces to oppose coercion from a vast depth of mathematical resource.

Although with glass, probably on account of its hardness in relation to the screw, it seemed impossible, before breakage, to obtain more than from three to six rings at either end, yet when a softer material, such as copal, was used, the column was wreathed in coloured bands from top to bottom. Observe the dark band between the blue and red. Its position is invariable whenever these two colours come together, and from the first my suspicions were decided that it marked either an unstrained path in the column or a division of equal antagonistic forces. In fact, we must not regard the bands as horizontal strata, but rather as sections of oblique planes which follow the directions of stress. (See diametric sections *A* and *B*, which are the negative and positive images of the same object.)

It was with a view of assuring myself of the truth of these suspicions, that I one day asked permission to search through the store-room of the Illinois and St. Louis Bridge Company for corroborative phenomena. In this room were many objects, crippled and otherwise, which had been tested in the testing machine belonging to that company, and I was in hopes of finding in changes of form some assimilation to the arrangement of colours in the glass columns, and especially something to corroborate the neutral character of the dark line, as already provided. There was no want of testimony in any piece of the existence of a wave action in the pressure, but in the solid bars this was confined to a cone-like flattening (upsetting) at either end, and a determined "bulging" in the middle for those compressed, which was reversed in those subjected to tension. It was common to steel, iron, wood and cement cylinders (see *L*). Attention, however, was soon concentrated upon the tubes, all of steel, which plainly exhibited a periodic wave apparently at regular distances from end to end. Not being prepared at the time to measure them carefully they were left for a future occasion.

Still further to test the matter upon material, which would yield form instead of colour to the forces brought to bear upon it, arrangements were made by me for a change of experiment.

[1] The writer will endeavour at a future time to present the concordance between the mechanical and optical phenomena, more in detail and with greater precision. For the present, relying mostly upon the success of the ultimate experiments to prove the law conceived to be true, he has preferred rather to suggest the line of argument than to closely follow it.

Definite trials were made upon brass tubes ·45 in. outside diameter, ·35 in. inside diameter, and a length necessarily confined to about 1·5 in. by the small clamp used. These were compressed longitudinally by a screw until the form assumed was permanent. *M* gives an idea of their original and assumed appearance. These trials have been carried through some 12 or 15 tubes and the results subjected to measurement, the storeroom of the Bridge Company was again visited, and a scale used to measure, as correctly as possible, the distance between the waves on the steel tubes. Then, with very little labour, the results were tabulated, and with not much more (since either the outside or inside diameter, or the radius of gyration, were almost obviously the base, and some oblique line proceeding from the axis of the tube outwards, as certainly the hypothenuse of a triangle of pressure) the following empiric expression was derived, which, so far as I can discover, will locate any wave in relation to another, the material of the tube being of course equally resistant from end to end. Measuring from ventral to ventral, we have when $x =$ distance, $R =$ outside radius, $r =$ inside radius, $a =$ constant quantity varying with the material alone and dependent upon the angle at which it most easily yields.

$$x = a\sqrt{\frac{R^2+r^2.}{2}}$$

This formula seems for brass tubes to become, as nearly as could be discovered,

$$x = \tfrac{5}{6}\sqrt{\frac{R^2+r^2,}{2}}$$

and for steel tubes,

$$x = \tfrac{7}{8}\sqrt{\frac{R^2+r^2,}{2}}$$

a being equal to unity. The steel tubes measured, varied from 1·5 to 2 and 5 inches in outside diameter, the waves on the only one of the latter present being perceptible, but faint except at the ends, from 1 to 42 inches in length, and from ·05 to ·25 inches in thickness of wall. They were 9 in number.

It became now necessary to show some cause for these phenomena and to bring their relations with the coloured rings in the glass column, and especially with the dark line between the blue and red, into closer connection. With this idea a theory already previsedin part from the coloured rings was taken up, with what appears to the writer a successful issue, as follows.

We learn from Rankine's "Civil Engineering and Applied Mechanics," that "no tangential stress can exist as a simple stress, but must be accompanied by another stress upon another plane, and that these two stresses have a resultant, which becomes a maximum when they are equal, departing from each at an angle of 45°."

Let us then consider the condition of a solid or hollow column, pressed evenly over the top by a great load, and resting upon a flat surface at the bottom. Evidently the weight must exert a tangential stress upon the walls of the hollow column, or the edges of the ultimate particles of a solid one, and as the longitudinal section of the column is rectangular, we may look for the accompanying stress to be at right angles to it. Let us for convenience consider these stresses to be equal, their resultant will have a direction between them and 45° distant, and if *K* represent the column, *A A'* and *A A''* will represent the resultants of the stresses. But these resultants act to push the material outwards at *A'* and *A''*, and as their action is, therefore, tangential or distorting, there results from our first law, and directly from this effect, two other "accompanying" stresses, *C*, *A'* and *C*, *A''*, which tend to draw the material atoms from *C* towards *A'* and *A''*. Now, where these stresses interfere at *A' A''*, they mutually neutralize each the vertical component of the other, so that there only remains at *A' A''* horizontal forces; and where they interfere at *C*, they mutually neutralize each the horizontal component of the other, so that there only remains at *C* the vertical component, equal to the weight at *A*, with which we commenced this discussion, and the plane *B*, *B'* is precisely in like condition as regards stress to the plane at *A*. It follows as a corollary that like conditions below *B*, *B'*, will produce like results to those at *A*, and *B*, *B*,' and so on for any number of equal divisions or periods; and it also follows that such planes as *A* and *B*, *B'*, &c., are unstrained by horizontal forces, and should, therefore, appear dark in the positive image, and that such planes as *A' A''*, &c., are unstrained by the vertical forces, and should, therefore, be dark in the negative image, which, in the bi-refractive glass columns, under polarized light, we find to be true, while in the metal tubes compressed we find a concording form.

L shows the form of the wave assumed by thin brass tubes—probably any thin tube—which has for its periods the same formula as the thicker ones, but differs in the vertical fold, and the consequent interlaced triangular section. It is probable that the vertical fold does not occur from any definite change, but only from a modification of our law, and may rather be regarded as a buttress, thrown out by tubes of a certain thinness, to resist transverse bending, and from thence propagated, by the natural pulling of the force of its creation, upon straight lines, and located by the well-known properties of the equilateral triangle as a perfect figure of equilibrium. Its position in the succeeding period midway between those formed above it, so that one triangle interlaces with and bisects the other, may also be accounted for by the fact that the middle of the side of the triangle is its weakest point, and the new buttresses are thrown out there in consequence of greater yielding at that place.

Remarks on Attendant Phenomena.

It was apparent during the course of these experiments on columns that each piece of material was mechanically polar, or, in other words, had a favourite end. This was shown in glass and brass by the end against which the screw-plate worked, yielding first. In the thick tubes, and in transparent columns, this was followed by the other end, and in the same tubes, and in softer transparent material than glass, by the intermediate ventral points. Of course, after a certain yielding in glass columns, the balance of compression was against the brass screws, which then yielded more in this direction than the glass, the glass column ultimately giving way by splitting down perpendicularly, as all vitreous substances naturally do, except a transverse crushing where the rings had appeared, making a nearly cubical fracture. In thin tubes the waves formed from the screw or active end towards the other end consecutively.

When, as frequently occurred, the tubes were not of exact length to make a regular succession of equal waves, then the difference was invariably made upon the base or passive end by a half wave longer or shorter than the normal half wave shown at each end in the drawings. In only one case was an abnormal wave noticed, this in a brass tube with an evident soft place in the material, which divided into five waves in the usual space for four, one wave coming within the soft place.

In the proposition it will be noticed that the lines *A A'*, *A A''*, *C A'* and *C A''* are straight. This was only the natural result of an attempt to investigate forces proceeding from one point to another. Subsequent experiments, which have not been as yet sufficiently wrought to publish, lead me to regard these as curved lines, and to consider the figure *A A'*, *C A''* as approaching an ellipse corresponding to the rhombus shown. The figures in the lower divisions would then, of course, suffer the same change from the same law.

I have thought if large, hollow columns yielded under the same law, and it should appear as apparent from the proposition and from other facts, that the law governs before the limit of elasticity was reached, then by reinforcing columns by bands shrunk on at the places pointed out by formulæ, we might greatly strengthen them at a small expense for additional material in the shape of rings (See *O*).

In conclusion, it seems to me, subject to higher decision, that the law of the periodicity of force in pressures, and probably in tension, has been fully proved in this paper, which will assist in accounting for the effects of re-occurrent applications of force and for the law of lamination under pressure, in planes perpendicular to the direction of pressure.

Mr. Charles Macdonald.—The experiments upon which formulæ in common use, for the proportion and strength of beams, are based, were made upon cubes of the materials tested; and it is found that the constants derived are inapplicable to ordinary cases in practice. It is known that a beam, loaded so that its outer fibres by formula should be under maximum strain, will stand a greater load. The constants employed in calculating the strength of a beam should be determined from experiments upon a similar beam of the same material, and not those given for direct tension and compression.

Mr. Alfred P. Boller.—A recent comparison of various standard formulæ for the strength of beams, made by taking a given beam and calculating, with each formula, its safe load, gave as follows :—two, 25 tons; one, 30 tons; and one 37 tons. The last was from Mr. Baker's formula, in which he has introduced the resistance due to flexion. The beam taken was 3 by 6 inches, and 5 feet long. Engineers should know more of the strength of materials. The formulæ used involve the application of constants ranging variously from maximum to minimum strength. These often differ widely, and, therefore, give uncertain results.

Prof. De Volson Wood.—The point of greatest interest

to me in the paper read, is whether the neutral axis is a line, or a space, as water in an eddy. In regard to the neutral axis and strength of beams, as determined by ordinary rules, the fact is, if we assume in a bent beam that the extensions and compressions are proportional to the distance of the elements from the neutral axis, and take the modulus of tenacity or of crushing, as the case may be, for the modulus of rupture of the beam, a beam proportioned in accordance therewith will have an excess of strength. To illustrate this, take the case of cast-iron, which is the best example in practice—the mean tensile strength (T) of cast-iron is 16,000 pounds, and the mean crushing strength (C) is 100,000 pounds, or, for convenience, six times as great as the other—96,000 pounds. If the beam is rectangular, supported at its ends and loaded in the middle, we have the well-known formula :—

$$\tfrac{1}{4} P l = \tfrac{1}{6} R b d^2$$

in which P is the weight, l the length of the beam, b its breadth, d its depth, and R the modulus of rupture. According to this theory, the value of R should be 16,000 lbs., but according to experiments it is found that the mean value of R for cast-iron rectangular beams is about 36,000 lbs. Former writers do not explain this discrepancy, but simply admit a defect in the theory, and pass it over by saying that a proper co-efficient of safety will make the formula a safe one. Barlow detected a new element of strength, which he called "resistance to flexure," a term which is unfortunate, as all the forces in a beam which resist bending, are resistances to flexure ; "longitudinal shearing resistance" is a better term, and one now used. This force is the resistance of the fibres to being drawn over each other. If there were no such resistance the fibres would retain their original length. To illustrate, suppose that several very thin but perfectly smooth boards of equal lengths were placed above each other, and supported at the ends. If now the pile of boards is bent, all the boards will retain their original length, and the ends will set past each other, as shown in fig. 3, but the general range of the ends will be parallel to each other. If we suppose that there is friction between the surfaces of the successive boards, the upper ones will necessarily be shortened, and the lower ones elongated. In a beam, the consecutive elements are united by cohesion, and Barlow found by a critical examination of those of cast and wrought-iron, that the transverse sections remained normal to the neutral axis during flexure, and in this case the ends will not be parallel, as seen in fig. 4. This being so, and bearing in mind the analogy between this case and that of the thin boards, we see that besides the forces which produce direct elongation and compression, there is a force between the consecutive elements somewhat analogous to friction :—this is longitudinal shearing resistance. Barlow found the laws which govern this resistance at the point of rupture, and modified the formulæ accordingly. The mode of his investigation and his results are fully described in the "Civil Engineer and Architects' Journal," vols. xix. and xxi. I consider them the most weighty and valuable sets of experiments that have ever been made upon beams, so far as theory is concerned.

Fig. 3.

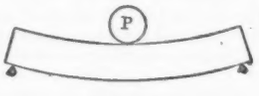


Fig. 4.

It is evident, the ordinary law that the strains vary as their distance from the neutral axis cannot apply to ⊥ sections, for to secure such action there must be at least a continuity between all the elements of the flange and those at the natural axis. Barlow made his formulæ applicable to this case, but it is equally evident that they cannot be rigidly correct. In all flange sections there is a peculiar combination of the strains about the angles where the flanges join the web, and it seems impossible to assign the laws which govern them.

Prof. Norton, of Yale College, determined from direct experiment the fact of a transverse shearing resistance in beams, and also the laws which govern it for rectangular beams. His article was published in the "Journal of Arts and Science," and in "Van Nostrand's Eclectic Engineering Magazine." I had detected the same analytically. If transverse elasticity only existed in a beam it would be deflected. To show this by a figure,—suppose that short portions of the beam were perfectly non-elastic, and that between these were elastic sections. Then will a beam which is supported at its ends, and loaded at the middle be deflected, as in fig. 5. If the beam has a continuous transverse elasticity, it becomes evident that the deflection will be as shown in fig. 6. The deflection due to this cause is additional to that due to Napier's theory, while longitudinal elastic shearing resistance will diminish it.

It is worthy of note that the strength of beams, as determined from Barlow's new formulæ and constants, agrees remarkably well with the actual strength for all the forms which he used. It is hardly to be expected that a simple law, or laws, can be given which will be applicable to all the forms of beams now used in practice. The constants which are determined from solid rectangular beams will doubtless apply practically to solid beams of all dimensions, but not to other forms. For instance, if solid cast-iron beams give $R = 36{,}000$ lbs., it will not be safe to use this value for hollow beams, or ⊥ beams. For such beams $T = 16{,}000$ lbs. is safe, but may give an excess of strength.

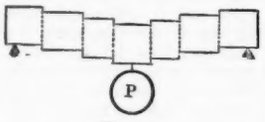


Fig. 5.

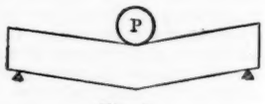


Fig. 6.

MR. BOLLER.—It is best to make a beam proportioned similar to those to be used. Break it and deduce therefrom a constant. The formulæ ⊥ beams are safer for thin than thick webs—say ¼-inch web and 4-inch flange.

PROF. WOOD.—The experiments of Baron Von Weber, "Engineering," 1870, showed that the web had never been made too thin. Where the flange and web are joined there should be a large curve.

MR. MACDONALD.—In T. C. Clarke's description of the Quincey Bridge, there is a statement that 12-inch ⊥ floor beams, 15½ ft. long, suspended in pairs from panel points about 12 ft. apart, and carrying a single track of 4 ft. 8½ in. guage, scarcely deflected under a maximum engine load, which caused a strain upon the outer fibres at least equal to 14,000 lbs. per square inch, according to formulæ in general use.

PROF. WOOD.—We should not proportion structures in reference to the ultimate strength of the parts, but in reference to their elastic limits. The elasticity of the material should not be damaged. Some irons which are very tenacious have a low limit of elasticity, while others, and especially certain grades of steel, seem to preserve their elasticity for a strain nearly equal to half their tensible strength. Capt. Eads, in the construction of the St. Louis bridge, insists upon preserving the elasticity of the steel, and very careful experiments are made to determine its elastic limit.

COL. W. E. MERRILL.—I regret I cannot give this as thorough an examination as I could wish. It opens a field for investigation that promises the most useful results in a matter of vital interest to engineers and architects, and in fact to every one ; the laws of the action of strains on materials used in construction, and the proper method of meeting and sustaining them with assured safety. Being quite unfamiliar with the use and laws of polarized light, I do not feel competent to discuss the very interesting results obtained, but the method chosen, and the means pursued, seem most admirable. The plan of using glass to find out the laws of steel and iron, reminds me of the practice of physicians in ancient times of determining the laws of the human body by experiments upon inferior animals. The limitations of sense having apparently put an insuperable barrier to the examination of the interior of opaque bodies under strains, the method by analogy seems the sole one that is open to us, aided of course by what we can see on the surface, and detect after fracture.

I have often thought it desirable to be able to see exactly how the strains in the different members of a truss bridge were working during different positions of the moving load. The method of Mr. Nickerson seems to offer that long-needed means. Further experiments will probably enable the experimenters to decide with fair accuracy upon the magnitude of an unknown strain on a glass column, by comparison with the observed effects of a known strain upon a similar column. I would suggest that a model of a Howe truss bridge be made with glass members and metallic joints, so constructed as to permit the ready insertion or removal of glass columns, acting as struts, ties and chord segments. I believe that such a model can be made and so adjusted that broken parts can easily be replaced. If then the method with polarized light be used, valuable information about points now somewhat obscure could be obtained so as to command universal credence.

The proposed strengthening of tubes by external rings, at regular intervals, is a very curious result of the experiments, and if confirmed by practice, will be a valuable discovery. The whole discussion illustrates most admirably the inter-dependence of all branches of physical science, and the absurdity of con-

sidering any discovery useless, no matter how far it is apparently removed from a possibility of practical application in the useful arts. Hitherto the polarization of light has seemed a curious and occult phenomenon, of no particular utility, and only interesting to the man of abstract science, and here it suddenly springs up as a trustworthy means of unveiling the secrets of nature, and promises as great a future of discovery as the spectroscope.

HON. WILLIAM J. MCALPINE.—As a practical question, the civil engineer has almost never to deal with glass as a material of strength, but it must be evident to all, that it will be affected in the same way as any other material of similar construction, and hence that the effects of strains upon glass will be similar to those upon cast-iron. At least the experiments made with such apparent care would be of great value in determining the law upon the subject.

It is a singular characteristic of this age that every discovery in science is made applicable to the service of our profession. Five years ago Prof. Airey (the Astronomer Royal) gave a paper on a new system of calculating the strains on each member of a truss, by a model in steel, which he had exactly duplicated. When the model bridge was loaded in all of the various ways, each member was struck, and the corresponding duplicate was loaded gradually until the two were in accord. The load on the duplicate indicated the strain on the corresponding member of the truss in position and under its load or strain. There we had *sound* to determine a most important engineering question; and now we have *light* in one of its forms of action.

GEN. J. G. BARNARD.—I have been unable to give the matters presented by Mr. Nickerson the study required for a full appreciation. I would remark, however, that the peculiar circumstances under which the experiments for the neutral line or axis are made, are really foreign to the subject of the position of that axis as it is presented to the engineer in connection with the theory of the strength and stress of beams. That theory and the formulæ deduced, are like nearly all our mechanical theories of the properties of matter based on somewhat rude assumptions. Moreover, the formulæ for "beams" really suppose the length to be very great, compared with the depth—practically infinite. No one supposes that, in pieces so short as the glass specimens experimented upon, the "strains," "stresses," and "strength" would be represented by the usual formulæ for "beams." That theory ignores all "strains," in the technical sense of the term, except those due to the elongation of fibre on one side of the neutral axis, and its forced contraction on the other. It is far from being a true exposition of the phenomena which are developed by the bending of a beam. The truth is limited by the imperfection of elasticity, and by any amount of deflection given to the beam beyond a very limited and exceedingly small amount; for tangential (or shearing) strains are disregarded.

The experiments upon pieces so short as those used by Mr. Nickerson develop phenomena which scarcely belong to the theory of beams, or to the position of the "neutral axis" in the usual acceptation of the term. I do not, in saying this, depreciate the value of experiments of that kind. They are directly applicable to the illustration of the strains produced in columns—and in all pieces subject to similar stresses. I would remark, too, that glass, to the extent to which it is capable of receiving change of form without rupture, is almost perfectly elastic. Iron is far from being so, at least beyond the narrow limit to which it may be distorted without "set."

I am not familiar with the investigations of Mr. Barlow, but if the stress in a bent cast-iron beam be a "uniformly varying" one, he must prove, I think, that the co-efficient of elasticity is constant for all degrees of extension. That co-efficient for wrought-iron varies in a table given by Morin (taken from Hodgkinson) to an extraordinary degree; being for extreme extensions only about $\frac{1}{25}$ of its value for very small extensions; though within limits of practical strains—say to about 18,000 pounds per square inch, the variation is small, say $\frac{1}{12}$ of its maximum. For cast-iron the co-efficient for extension exhibits some variation also, in practical limits of stress, that is, within limits of safety. For compression, both of cast and wrought-iron, the co-efficient is (within practical limits say up to 15,000 or 18,000 pounds per square inch) more nearly constant in both materials.

In the experiments[1] made by me on the strain and rupture of beams of forged and cast-iron (of dimensions never before experimented upon, I believe), the co-efficient of elasticity, as deduced from the assumption of a "uniform varying stress" in the cross section, and a central neutral axis, varies in one of the forged specimens from 1,482,000 to 9,558,600 pounds per square inch—the smaller co-efficient corresponding to the extraordinary extension of fibre of ·0463 and a "tensile strength" of 68,450 pounds per square inch—calculated from the amount of deflection of the beam)—and this extraordinary extension and this high tensile strength is exhibited in the iron of a *heavy forging*—*i. e.* in a forged beam, 15 in. by 12 in. in rectangular section. On the other hand, a cast-iron beam of the same dimensions, rupturing under a force of 276 tons with a flexure of $\frac{3}{8}$ in. (the supports being 77 in. apart), exhibited a (calculated) extension of fibre of ·00573[1] and a co-efficient of elasticity of about 40,000,000 pounds per square inch; and at the lesser flexure of $\frac{1}{4}$ in. (the only other observed), the co-efficient was about the same.

The variation of the co-efficient of elasticity under different degrees of extension, seems to me to be proof positive that in a bent beam there cannot be "uniformly varying stress," for while the extension of fibre varies, as it must do, nearly uniformly from the neutral axis to the exterior, the co-efficient of elasticity, the constancy of which is essential to a corresponding uniformly varying stress, is, in wrought-iron, far from being constant. The co-efficients for cast-iron vary much less than for wrought-iron—and indeed, my experiment just cited, with a cast-iron beam, while developing an "extension" of ·00573, which is nearly four times as great as the maximum extension in the table of Hodgkinson's results, given by Morin[1] ·00155, indicate at that extreme extension the same co-efficient nearly, as for the less extension of ·00382. Hodgkinson (as quoted by Morin) gives almost identical co-efficients of elasticity for cast-iron for compression as for extension: hence it may be presumed that the same is the case in the cast-iron beam ruptured by me.

There is, therefore, in this important experiment—the largest beam, I believe, ever ruptured experimentally—some confirmation that, for cast-iron, Barlow's theory is true, viz., that the stress in the cross section *is* a uniformly varying one, and that the neutral axis "transverses the centre of gravity." Yet from this experiment we deduce a discrepancy between the "modulus of rupture" and the "tensile strength" of the iron, even greater than for the case of the wrought-iron beam in which enormous variation in the co-efficient of elasticity is clearly shown. The modulus of rupture for the 12 by 15 in. cast-iron beams would be, in one case, nearly double—in the other about 1·5 times the "tensile strength."

Mr. Barlow is probably right in the opinion (as stated by Rankine), "that the curvature of the layers of the beam produces a peculiar kind of resistance to bending, distinct from that which arises from direct elasticity." It is evident that the theory of a horizontal neutral axis, however convenient, cannot be a true representation of the phenomena of the resistances developed in bending a beam.

Let us suppose the solid rectangular beam *A*, *B*, *C*, *D*, fig. 7, resting upon supports at extremities to be bent to a *given deflection* by a force *P* applied at the middle. The neutral axis along the middle (according to theory) would be the line *m n*, and moreover the entire horizontal section *m n* is in a rectangular section (or other symmetrical section above and below this plane), reckoned as neutral. But it is evident that it cannot be strictly so—evident that to stresses transmitted across it the three-fourth's

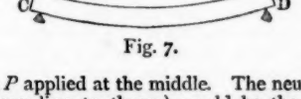


Fig. 7.

Fig. 8.

computed resistance to flexure is due. For, let the beam be split along the section now, it will become two beams, of which the contiguous surfaces *m n* will slide over each other, and, the flexure being maintained the same, the two halves will appear as in fig. 8, and the force to produce the flexure will be but $\frac{P}{4}$. There cannot, then, be a neutral line or plane along *m n*, and it may be doubted whether there can be really neutral lines or planes *anywhere* in a bent beam.

Researches with a perfectly elastic material, as glass, and one, too, which can be made to reveal to the eye indications of its

[1] Transactions XIV.

[1] On page 5 of the paper referred to, there are errors in the printing of the figures for the "extension of fibre." They should be ·00382 and ·00573.

[2] "Résistance des Matériaux." Morin, 1855.

internal strains, cannot but throw light upon one of the most difficult problems in mechanics, viz., the internal strains of solids subjected to the action of external or internal forces. The general problem can be stated mathematically; but the analytical solution, except for a few simple cases, defies mathematicians. That portion of Mr. Nickerson's researches concerning the strains in hollow columns is very interesting, and I am inclined to regard his views on the "periodic" character of the strain, and upon the means of counteracting it, as well founded.

MR. E. A. FUERTES.—Some time ago I noticed a flare or wing-like streak of light when examining the image of a star through my equatorial telescope. Fearful of some accident having taken place and impaired the object glass, and not being willing to remove it from its cell, I held in front of it a spirit lamp, on the wick of which I had poured some common salt. I at once observed the formation of Newton's rings on the lenses, but near the edge of the cell holding the lenses, the rings, instead of being concentric, were scalloped, or bent inward toward their centre. Remembering experiments made by Pasteur, upon the pressure of mercury over a thin glass surface, I further examined the cell, and found that the disturbance of Newton's rings occurred near one of the screws which held the cell on the barrel of the telescope. I loosened the screw, and to my great and natural delight, the interference suddenly disappeared. It was then evident that the cell had contracted through cold since the time at which it was screwed in the telescope, and that the pressure produced by this contraction caused the imperfection of the image, the location and extent of which was revealed by the soda light.

GEN. T. G. ELLIS.—Several years ago I gave much thought to the subject of strains in beams, and regretted that those who had given their attention to experimenting, had pursued their investigations in so unscientific a manner. Mr. Nickerson's examinations are a step in the right direction, although I do not see that he has developed much more than has heretofore been done by Wertheim of Paris, who invented an instrument for the determination of strains and pressures by the colours of polarized light. Professor Tyndall has also done the same. I sincerely hope that Mr. Nickerson will pursue the matter further. What we want to know is the elastic resistance to tension and compression in any one substance, as glass, and the effect of a weight upon a beam of the same substance. Then, knowing by experiment the elastic resistance in both directions of other substances, we might reason with some hope of success upon the position of the neutral axis of beams of different substances. In my opinion a great error of writers on the strength of beams is, in assuming that equal strains will elongate and compress the same substance to an equal amount, thereby making the neutral axis of the horizontal strains in the middle of a rectangular beam; also in assuming that the elastic resistances are proportional to the ultimate resistances of the material.

One part of Mr. Nickerson's experiments that I do not clearly understand, is, how polarized light can show a neutral axis in a glass beam supported at the ends with a weight in the middle. It seems to me that it should show only a neutral *point* in the middle of the beam, under the weight. There are diagonal strains in all parts of the beam except this central point, and diagonal strains should transmit the polarized rays as well as the horizontal ones. That there are diagonal strains in all parts of the beam, although they may be very small in the upper end corners, may be shown by supposing the whole to be divided into very thin horizontal laminæ. The flexure of the beams by the weight would then cause all of these to slip one upon the other. This is resisted in the solid beam by the diagonal resistance of the material. The additional element of strength referred to in the paper, is, I apprehend, not due to the absolute resistance of the material to the sliding of the laminæ upon each other, or the "horizontal shearing strength," as it has been called, but to the elastic yielding of the fibres of the material, which, without diminishing their ultimate strength, allows them to slip, so to speak, upon the next interior fibre, so that the latter are drawn to a greater tension, or subjected to a greater degree of compression than they would be if there were no such lateral elasticity between the fibres. The outer ones would be ruptured as soon as their limit of elasticity was reached, and before a full strain was brought upon any of the interior fibres, were it not for this action.

GEN. J. G. BARNARD.—I am disposed to think Barlow's position untenable, that the neutral axis *cannot* be in the centre of gravity, when the breaking strain is in excess of the result given by formulæ founded on that assumption. There is no more radical law of mechanics, than that the forces across any section must be in equilibrium. Take a cross section of a beam, and these forces cannot be in equilibrium if the neutral line is through the centre of gravity when the breaking force is found to exceed that due to the tensile strength of the iron.

PRACTICAL PAPERS ON DESIGNING MACHINERY.

(IV.)

IN our last paper we considered the principles and relations of specific heats and specific gravities, and showed how the falling of a lead bullet and the heat generated by its sudden arrest illustrated the convertibility of "heat" and "work;" it remains for us to apply the same principle to the work done in filling the water-tank; the bulk measure of water to be raised per hour is 10,000 gallons, and one gallon weighs 10 lbs., hence the total weight of water to be lifted is 100,000 lbs. up to a height of 135 ft. in the same time. If a lead ball—to retain the simile used in our last—weighing 100,000 lbs. were allowed to drop from a point 135 ft. from the ground, and that, just for the sake of illustration, it travels at such a rate of speed that it occupied one hour in falling, then the increase of temperature generated by its sudden arrest would precisely represent the quantity of heat requisite to lift the quantity of water above stated and place it in the tank. To put the thing more exactly, we must refer to another set of Nature's laws, a set that exercise a very large influence on mechanics, viz. the laws regulating the velocities of falling bodies. It will probably surprise our younger readers a good deal to hear that if a lead ball and a feather are let fall in a perfect vacuum, or as nearly perfect a one as can be made in the receiver of a good air-pump, both bodies will fall at exactly the same speed, and if let drop simultaneously, will reach the bottom together, the only reason why such a result does not take place if done in the open air of a room, is simply that the feather offers so much a larger surface to the air in proportion to its weight than does the lead ball.

Neglecting the influence of the air just for the present, we may merely state that the velocity of any body falling to the earth is always a certainty, and progressive in a fixed proportion shown in the annexed table.

Table of falling bodies.

Time in seconds . .	1	2	3	4	5	6	7	8
Space in feet	16	64	145	257	402	580	789	1030
Final velocity in feet per second . . .	32	64	96	129	161	193	225	257

It is evident now that any body of reasonable density, such as will not be sensibly affected by the resistance of the atmosphere, will, after falling 135 ft., have attained a velocity of about 94 ft. per second, and take nearly three seconds in falling, and on this motion being suddenly arrested, the corresponding increase of temperature is the result. A lead ball one ounce weight, and one weighing over 100,000 lbs. will, practically speaking, fall with equal velocity, and each when arrested would show on the thermometer the same increase of temperature, were it not for other points, to be dealt with presently; then, as there is say 16 oz. in a pound, of course there is 1,600,000 times as much lead in the large as there is in the small ball, and therefore 1,600,000 times as much heat. The next step is to find out how much heat, measured in units, there is in the large ball at the moment after its stoppage. If we take as a measure of heat that quantity of it which will suffice to raise 1 lb. weight one foot high, or on the other hand, the quantity of additional heat present in a pound weight of any substance at the instant after it has dropped 1 ft. and struck the ground, we can make a calculation for our ball weighing 100,000 lbs. and falling 135 ft.; for then it only remains to state a simple sum in multiplication, as follows: 100,000 × 135, which equals 13,500,000 measures, consequently this is the quantity of heat necessary to replace the ball or take the water up from the well to the tank. Perhaps some of our readers may say, "You have a whole hour to lift the water, whereas the ball descended in a few seconds." The reply is, that—neglecting extraneous disturbing causes of air resistance, friction, &c., the price to be paid remains the same; it may be paid all at once, or it may be divided over any reasonable period of time, such as the hour in the present case. Our readers may ask the question also, "You say your lead ball will show so many degrees increase of heat after its fall; but if the ball be, say, of wood or brass, surely the wood ball, for example, will not be any warmer?" This last is a question involving very subtle points of the laws of heat. First we have our table of specific heats; the specific heat of a body only means its relative capacity for showing the heat on the thermometer; but there are other

points concerned also in the action of the heat acquired by a fallen and suddenly arrested body—the heat is being actively employed in causing the body to descend, gravity being the exciting cause calling the heat into action—gravity calls the heat to act in moving down the ball, but until the string is severed the heat must remain inert. Then for what we have stated already concerning the restoration of this heat on the arrest of the ball, the following points complicate the question thus: 1st. When the falling body strikes the ground, the latter receives a portion of the heat. If the ball and the ground plate which it strikes are both of like material, each will receive exactly half the total quantity, but if the two be of different materials, then another law intervenes, viz. that each body has its own rate of heat reception—this is not exactly a question of conductibility, but is nearly allied therewith. To make this difficult point more clear, we will put it thus: one ounce of lamp-oil of a certain kind contains a given quantity of carbon, which, when mixed with oxygen, will give out a fixed quantity of heat. Now, if a wick is fitted to this lamp of a size which will consume this oil in ten minutes, evidently all the heat is evolved in the same time. For sake of proceeding as simply as possible, we stated above that if a lead ball and a wood ball were held over the lamp for the same time, each would receive exactly the same quantity of heat, but now we must explain that this is not precisely scientifically correct, for the reason that, as each substance receives heat at its own rate, naturally a fixed quantity of carbon must be consumed in the lamp at a different rate by a different sized wick if each is to receive all the heat. In reference to this we cannot do better than quote Prof. Tyndall's admirable work, "Heat considered as a mode of Motion." Our readers must not imagine this title as meaning work done by heat in moving bodies, or the mechanical effects of heat; simply it means the arguments advanced by this and other great philosophers to prove the correctness of the theory that heat is simply a motion amongst the constituent atoms of any body. The passage is as follows—he is speaking in a lecture on falling bodies and the heat generated by their sudden arrest: "In order to imprint on your minds the thermal effect produced by a body falling from a height, I will go through the experiment of allowing a lead ball to fall from our ceiling to the floor. The ball is at the present moment slightly colder than the air of this room; this is proved by bringing it into contact with the thermo-electric pile.[1] Here on the floor is placed a slab of iron, on which I intend the ball to fall. The height is too small to yield much heat by a single fall, it will therefore be drawn up and allowed to fall two or three times in succession. Observe there is a length of covered wire attached, so that I do not touch the ball with my fingers, but take it by the wire, therefore my hand never comes near it. Now, after the fourth fall, I place it to the instrument, and the immediate deflection of the needle shows at once that the ball is heated; this heat is entirely due to the destruction of the moving energy of the falling ball when it struck the plate. What is the total amount of heat thus generated? The space fallen through by the ball in each fall was 26 ft.; the heat generated is proportional to the height through which the ball falls. Now a ball of lead falling through 772 ft. would generate heat enough to raise its own temperature 30° F., its capacity (for heat) being $\frac{1}{30}$ that of water; hence in falling through 26 ft., which is in round numbers $\frac{1}{30}$ of 772, the heat generated, if concentrated in the ball, would raise its temperature one degree. This is the amount of heat generated by one descent of the ball, and four times this would be of course generated by four descents. The heat, however, is not all concentrated in the ball—it is divided between the ball and the plate on which it descends."

Now, if a ball of lead have a receptive rate for heat peculiar to itself, and a ball of gold one of its own, we then know that the same quantity of carbon must be burned under each at a different rate, and this then complicates the test of work done by letting the ball fall and gauging its heat with a thermometer, because if the material which arrests the ball have a more rapid receptive power than the ball, it will get a proportionately greater quantity of the heat, but the principle we are trying to explain remains the same, for the heat imparted to the ball and ground plate is collectively that amount which would just restore the ball to its original place. In such papers as these it would be out of place to go into all the subtle analyses of the operations of heat, we only now place the above before our readers to indicate the general nature of the principles on which heat and work depend; those of our readers who desire to study the operations of heat cannot do better than read Tyndall's work above referred to.

[1] An instrument much more delicate in its action than a thermometer, and showing differences of temperature by moving a needle as in a telegraph.

We now may return to the boiler for our pumping engine, and having ascertained the theoretical quantity of heat we require, proceed to ascertain the amount of coal to be burned to get this heat. As has been already stated in the last number of these papers ("Practical Magazine," No. 22, page 294), heat is derived for every-day purposes from the combination of carbon and oxygen. The chemical combination of other ingredients also yield heat during the process, but it is sufficient for our purpose at present to consider the combination of carbon and oxygen only. The former of these bodies may be most familiar to our readers if we call it charcoal; charcoal, as probably they know, is made by heating blocks of wood in iron vessels from which oxygen is excluded, and the heat volatilizes all its gaseous constituents, or, more strictly speaking, sets them at liberty; the charcoal which remains is chiefly carbon, but there is an admixture of incombustible substances also, such as silica, and in some woods potash, this last being present in such quantities in some woods, that the burning of them in many of the forest districts of America and Canada, for it alone, forms a regular trade. Carbon combines in two different proportions with oxygen, the resulting gases being respectively carbonic acid and carbonic oxide; carbon exists in different quantities in different coals and woods; the diamond is the only known example of absolutely pure carbon; plumbago or the black lead of a pencil is also nearly pure carbon, having occasionally a trace of iron.

In order to obtain the heat required for our pump, we must place coal upon a grate, ignite it, and pass a current of air through it. Air consists of 79 volumes of nitrogen and 21 of oxygen in each 100 parts, and, by weight, of 77 parts of nitrogen and 23 of oxygen in each 100; the oxygen, having a greater affinity for carbon than for nitrogen, leaves the latter when in the furnace, and unites with the carbon, evolving both heat and light during the operation, the resulting gases escaping up the chimney, as does also the nitrogen. Now, the combination of oxygen with carbon is essentially a chemical operation of the laws of the affinities of certain bodies for each other in particular proportions, and owing to this, if we desire to burn 1 lb. of carbon in our furnace we must pass a special quantity of oxygen through the furnace bars, and as the bulk of the oxygen is but a fifth of that of common air, evidently a corresponding quantity or volume of air must be sent through them and the burning fuel. Even in a chemist's laboratory, where perfectly pure oxygen and carbon can be obtained, they are found to combine in two different ratios, yielding respectively carbonic acid and carbonic oxide; then evidently under the less perfect conditions present in a boiler furnace it is not easy to determine the exact quantity of air proper to pass through a given charge of coal contained and burning within it. It may, however, be approximately stated that about 12 lbs. of air contains enough oxygen to burn 1 lb. of coal; in practice, however, owing to the difficulty of bringing the oxygen in perfect contact with every particle of the fuel, from 18 lbs. to 24 lbs. of air must be passed through the furnace for each pound of coal burnt, so here is another link in our chain of the operations involved in our pump and its working. The next link to get is to ascertain the number of units of heat contained in 1 lb. of coal; to be very scientific, perhaps we ought to say, contained in 1 lb. of pure carbon, but as no such commodity can be had for steam boilers, and as besides this we desire to adhere to our rule of simplicity and practical handling of our subject, it will suffice if we state the number of units contained in 1 lb. of coal and the respective evaporative powers of different samples of coal as set forth in the annexed table, which shows the leading particulars of enough samples for our present purpose.

Name of Coal.	Specific gravity.	Carbon.	Oxygen.	lbs. of water evaporated by a pound of coal.
Welsh coal:				
Craigola	1·30	84·87	7·19	9·35
Coleshill	1·29	73·84	8·29	8·00
Merthyr	1·31	82·8 to 91·2	1·65 to 2·63	9·73 to 10·16
Rock Vause	1·29	77·98	8·55	7·68
Lancashire coal:				
BalcarrasAbbey	1·26	83·54	5·87	8·83
Black Brooke	1·27	80·47 to 82·70	7·20 to 8·99	8·02 to 8·29
Wigan cannel	1·23	79·23	8·99	7·70

As to the number of units of heat in a pound of coal, we shall consider that point by proceeding to apply the principles we have now educed to the determination of the quantity of fuel we must burn per hour in our grate, first theoretically considered, and then as practically applicable in ordinary working. For the theory purely, as worked and applied under the most scientifically perfect conditions, we must see what is the real

working value of this same subtle agent, heat. We have shown that a falling body suddenly brought to rest evolves heat enough between itself and its arresting body to restore it to its original place, we have also seen that the proper combination of carbon and oxygen yields heat, and that to restore the fallen body to its place, or to pump the water into our tank, we must expend a certain amount of heat : consequently to raise the body we must burn as much carbon, or the coal containing it, with oxygen drawn from the air, as will yield the requisite heat ; let us see how much we require. Professor Joule, of Manchester, by careful experiments made several years ago found that the quantity of heat requisite to raise 1 lb. of cold water, or say water at 40° F. one degree in temperature would raise 772 lbs. 1 ft. high, or conversely 1 lb. 772 ft. high, or 77·2 lbs. 10 ft., or 7·72 lbs. 100 ft. high. In order that all the relations of heat and work may be as clear as we can possibly render them to our readers, we will roughly sketch the outline of the way such a point as this invaluable one of Professor Joule's is determined. Suppose a lamp be taken and trimmed carefully and lit ; then imagine two balls, say, as we have so frequently used the same illustration and retaining it now, of lead each weighing 1 lb. and in every respect identical ; that one of these be suspended by a slender thread above a hard flat surface 10 ft. below its centre of gravity which is, of course the true centre of a sphere, a thermometer is applied to the ball and its temperature is found to be say 70° F., the string is divided, the ball drops, and the thermometer is again applied ; then—we will suppose—the ball is 72° temperature ; this is noted down. Now then, the second ball, or for that matter the first one after it has cooled to 70° again, is held suspended over the flame of the lamp till it has again warmed to 72°. Here it is perfectly evident that the quantity of heat imparted to it by the lamp, if used in doing active work, would raise the ball the 10 ft. down which it dropped, making, of course, due allowance for the heat taken up by the plate on which the ball fell. Of course if the experiment were carried out on a large scale, and it were possible to arrange that the entire heat evolved by the lamp flame should be absorbed by the ball for the time being, then the determination of the actual quantity of oil burned while the ball was heating, and a perfect analysis made to find the quantity of carbon contained in the oil, would at once show, speaking scientifically, the quantity of carbon to be burned if we wanted to raise the ball the 10 ft. by machinery.

From experiments on this principle, but, of course, with most elaborate appliances, Professor Joule obtained the factor of 772, and it is universally known to scientific men and engineers as Joule's equivalent, and by it we know that a unit of heat is that quantity of it which suffices to heat one pound of cold water 1° F., or lift one pound 772 ft. high, and it forms the basis for determining the relative economy of different power machines, whether they be men, the common beasts of burden or draught, or ordinary mechanical contrivances made by man, whether they be wind or water mills, first-class marine engines, or locomotives. Applying this test to our fuel, it has been ascertained by careful experiment that one pound of good Welsh coal, such as Merthyr, for instance, will, if all the heat be passed into the water, evaporate 15 lbs. of water; a pound of water converted into steam, absorbs during its conversion, in round numbers, one thousand units of heat ; hence the pound of coal contains enough carbon to evolve when mixed with the due proportion of oxygen 15,000 units of heat, each unit suffices to lift 772 lbs. a foot high, consequently the pound of coal when burnt under the due conditions would yield a power equalling 15,000 × 772 or 11,580,000 lbs. raised one foot high ; taking now Watts' measure of a horse-power as being 33,000 lbs. raised one foot high, then this shows how far removed are our best steam-engines from perfection. Assuming, for argument sake, the results of experiments made by Favre, Joule, Silberman, and other eminent investigators of this subject, which show that a pound of good coal, the carbon of which is perfectly consumed, yields 15,000 units of heat, we have at once 15,000 × 772 = 11,580,000 foot pounds, or pounds raised one foot high ; 33,000 lbs. raised one foot in one minute is a Watt horse-power, and this multiplied by 60 makes 1,980,000 per hour realized by the consumption of one pound of good coal in the same time, and 11,580,000 ÷ 1,980,000 = nearly 6 Watt horse-power, being what we ought to realize from a steam-engine ; our best engines by such a rule should only burn one-sixth of a pound of coal per indicated horse-power per hour; as it is, very excellent engines, indeed, use 2½ lbs. or 15 times this quantity. Of course, we must bear in mind that nature keeps her debtor and creditor account so nicely balanced that she takes toll of us for the work done in supplying air to the furnace. We have seen above that a certain quantity of air must be passed through the grate bars to consume each pound of coal, and some degree of force is also requisite to overcome the friction of the air against the bars, and while finding its way through the burning and sometimes freshly put-on fuel ; then there is the friction in the tubes, or flues, and in the stack, and as the air must necessarily enter the fire at a velocity proportionate to its consumption in the furnace, as a mâtter of course the gases and products of combustion, the carbonic acid, carbonic oxide, smoke, &c., must, especially as the gases are expanded by heat, pass even more rapidly up the chimney and as they all weigh something, work is done in passing them up the stack, and if there is no tall chimney on the one hand to make a natural draught, then a fan or other blowing machine must be employed to force air in, which also involves work done, and, of course, this accounts for a portion of the loss of heat demonstrated by our analysis above. Then from the velocity with which the heat is hurried along over the plates of the boiler they have not time to absorb all of it, and, of course, the residue escapes to the atmosphere.

We now come to the question of the material for the plates of our boiler. Although it would naturally appear that the metal which conducted heat most rapidly would be the best for boiler furnace-plates, if suitable also in other respects, yet some eminent scientific examiners into this affirm positively that the conducting power of a plate has nothing to do with evaporation. We, however, although holding our own opinions on this point, feel that an elaborate dissertation on the question would be out of place here, and so pass on, referring our readers to the annexed table, which shows the respective capabilities of metals and some other bodies in this respect :—

Heat-conducting Powers of various Bodies, Gold being the Standard Unit.

Gold	1,000
Silver	973
Copper	898·2
Platina	381
Iron	374·3
Zinc	363
Tin	304
Lead	179·6
Marble	23·6
Porcelain	12·2
Fire-brick	11·4

Of these several substances it will be perceived that gold, the king of metals, has the greatest power of conducting heat, then silver, then copper. Of course only two materials in the table are available for furnace construction in steam boilers, viz. iron and copper, and the latter metal is seldom used, save in the fire-boxes of first-class locomotives, as its expense is so great, and besides this, its soft and ductile nature, while rendering it easy to work and shape out, makes it incapable of sustaining great pressures without much support by stays. Consequently iron is the material most generally used in boiler construction.

As regards the passage of the heat from the furnace through the plate to the water, its rapidity depends greatly on the differences of temperature between what may be called the hot side and the wet side of the plate. That on the hot or fire side depends on the pressure of draught of air and consequent intensity of combustion, because, of course, as a pound of a given fuel contains locked up in its contained carbon a given number of units of heat, evidently, if we burn one pound in half the time allowed for the consumption of another pound, then, of course, the temperature is intensified proportionately. Our readers must be careful to distinguish clearly between quantity and intensity of heat. Thus, as we have explained before, about the quantity of heat present in a given tube full of air of a certain temperature, the compression of the air into a small space also compressed, and consequently intensified, the heat contained therein ; but the mere quantity remained the same, allowing for work done within the air itself in resisting the compression.

We have stated above that 1 lb. of good coal contains 15,000 units of heat. Well, now, this, theoretically speaking, should convert 15 lbs. of water into steam, or in other words, 1 lb. of water evaporated gives 1 lb. of steam, and such pound of steam contains 1,000 units of heat. In a steam boiler of good construction 9 lbs. of water will be converted into steam by the consumption of 1 lb. of the coal under notice. This being so, we can, in a rough and simple way, determine approximately the rate at which heat passes through the boiler-plates. If we direct our 15,000 units of heat against a horizontal plate, water being above on its upper surface, theoretically, as we have already seen, 15 lbs. of water should be evaporated. We know this by knowing 1 lb. of heat to contain 1,000 units of heat. We will assume the size of the plate to be a foot square, a good boiler will convert 9 lbs. of water into steam in one hour for each square foot of heating surface—or surface exposed to heat—which it contains. Thus, for example, a boiler containing 100

square feet of such surface will evaporate 900 lbs. of water; then, if all the heat in 1 lb. of coal really evaporated in practice 15 lbs. of water, and did so in one hour, the heat passing through the plate 1 ft. square, of course the speed with which the heat passed through the plate would be at the rate of 15,000 units per hour. This cannot, however, be accomplished in practice, so, taking an evaporation of 9 lbs. of water, we find that the rate is 9,000 units of heat passing through each square foot of plate per hour, the remainder passing away up the chimney.

We come now to the question of how best to save as much heat as possible from passing away up the chimney to waste. We have just stated that every square foot of heating surface in a good steam boiler will transmit heat enough to convert 9 lbs. of water into steam, but our readers must not by any means imagine that each square foot evaporates alike; very far from it, some parts hardly evaporate any water, others evaporate nearly the maximum amount possible; this is governed by working conditions at both sides of the boiler plate. Taking first the hot side, a horizontal plate with the water above it does the maximum evaporation because heat has ever an upward direction; vertical plates are not more than about one-fifth as effective, or 5 ft. of such surface will only equal one of the other; as a matter of course a horizontal plate, having the heat of the surface above, practically does no evaporative work whatever, and cold or nearly cold water has been obtained from the space beneath the ash-pan plates of boilers under full steam at the time. Again, another difficulty in the way of getting the heat into the plate presents itself in that property of dry gases, viz., their very defective heat-conducting powers; indeed, they have in some cases none at all, and consequently if we suppose a tube 10 ft. long and filled with the heated gases passing on from the surface to the chimney and regard these gases as a rod, or better still regard them as a piston of water, when this piston of water starts at one end of the tube the heat is drawn from the rim in contact with the inner surface of the tube, and the heat begins to leave the water; and suppose also that the heat only leaves the water next the tube surface first, then leaves another ring, then another, suppose also that as the heat leaves each ring of water, the latter freezes to ice, which ice offers great obstruction to the passage of the heat from the next ring of water, evidently when a couple of ice rings are formed no more heat can leave the water piston, and if it be passing along a tube 10 ft. long, and that the ice ring or rings be formed after it has traversed 2 ft., certainly it will pass over the other 8 unchanged. Very well; substitute a piston of heated gases for one of water, and the thing is plain; all the heat is drawn from the part of the piston next the tube, and this becomes then an impenetrable barrier against the passage of the heat in the centre of the piston, which accordingly goes on its way and yielding a portion of work in maintaining the rarefaction in the chimney necessary to support draught, the residue goes to waste.

THE PRACTICAL NOTE-BOOK OF TECHNICAL INFORMATION USEFUL TO STUDENTS AND WORKMEN.

(87.)

ORNAMENTAL Woodwork.—In fig. 448 we give a simple design for a paling, the height *a b* being divided into thirteen equal parts, and the various measurements being taken from one or four parts of these. The ledge *c d* is equal to one of the parts in *a b*, the centre of it being at the eleventh point; the part *g f*, is in the centre (*e*), between *d* and *l*. In fig. 449, we give the upper part of another design for a perforated or open-work paling or enclosure. In place of finishing with *a a*, the design in fig. 450 may be substituted; fig. 451 is the lower part of fig. 449. In fig. 452, we give a design for a central part or finial, which might be used in elaborate art or perforated paling or balustrade work. Fig. 453 is a design for a pendant, or the lower part of a paling or balustrade. Figs. 454, 455, are brackets.

(88.) **The Students' Note-book of Working Drawings.**—In fig. 456 we give the first course of an angle in Flemish bond brickwork; and in fig. 457, the second course. The reader will find in the last note given under this head the elevation and plans of work in this bond. In fig. 456 *c c* are "closers," *a a* "stretchers," *b b* headers; *b' b'* are half bricks; scale three-quarters of an inch to the foot. In fig. 458 we give the front elevation of a chimney stalk at its upper termination on English bond, of which in fig. 459 we give the plan of first course, and in fig. 460 plan of second course, all the courses in fig. 458 being but a repetition alternately of these two courses.

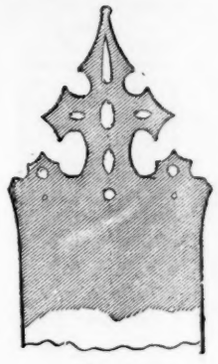


Fig. 450.

The lower drawing in fig. 459 is a section on the line A B; the lower drawing in fig. 460 is a section on the line C D; scale, half an inch to the foot. The chimney is what is called a

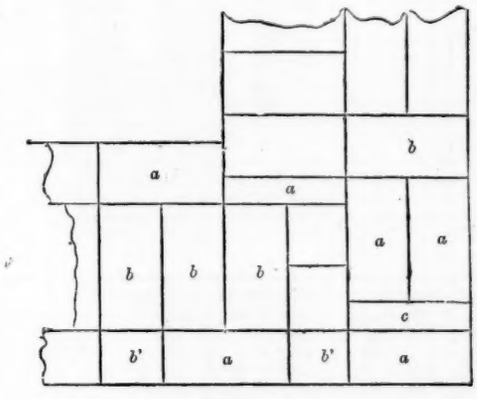


Fig. 456.

"double flue," and has on each side of the central division (the divisions between the flues are called "withs") three flues 14 in. by 9 in., the usual dimensions for an ordinary room; and one *c* 14 in. square, which is a "kitchen flue" of average dimensions.

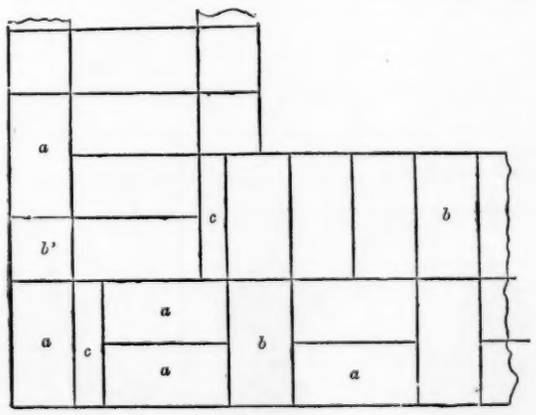


Fig. 457.

(89.) **The Elements of Cabinet Making Design.**—In fig. 461 we give in lower part of drawing (A A) elevation of the front of a wardrobe, with dimensions marked; and in the upper part of the drawing, the various sections on the lines in the elevation, as *a b*, *c d*, *e f*, and *g h*. Fig. 462 is a design for inlaid work; two methods *d c* are shown by filling up the various

Fig 448.

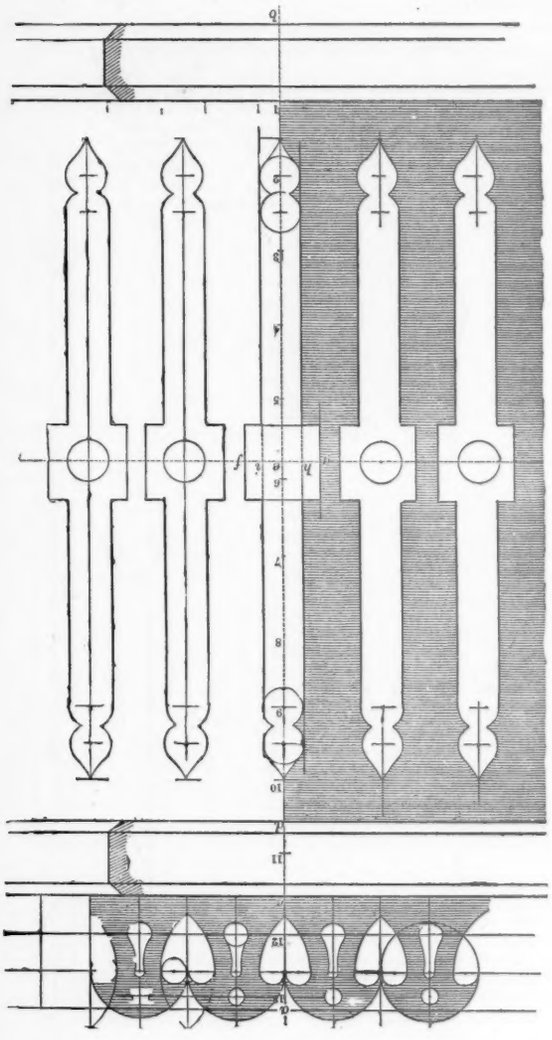


Fig. 449.

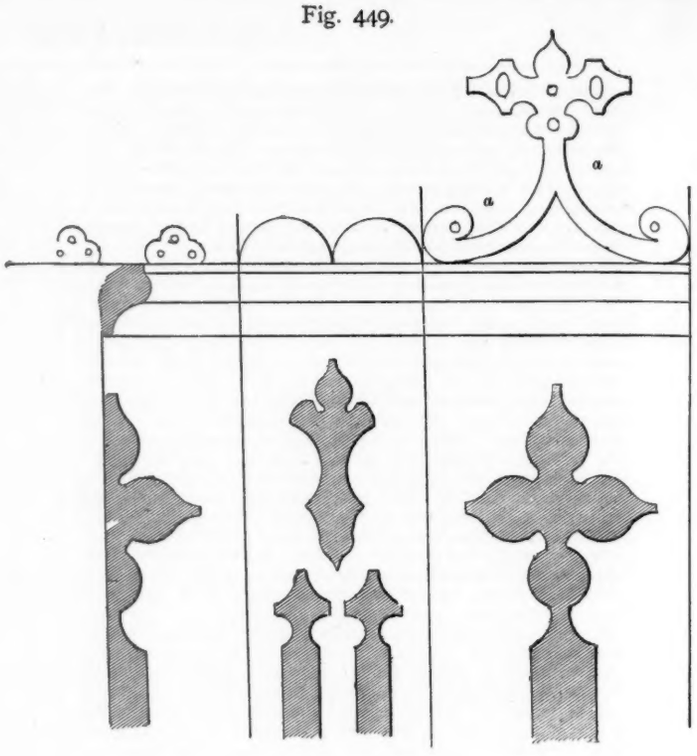


Fig. 452.

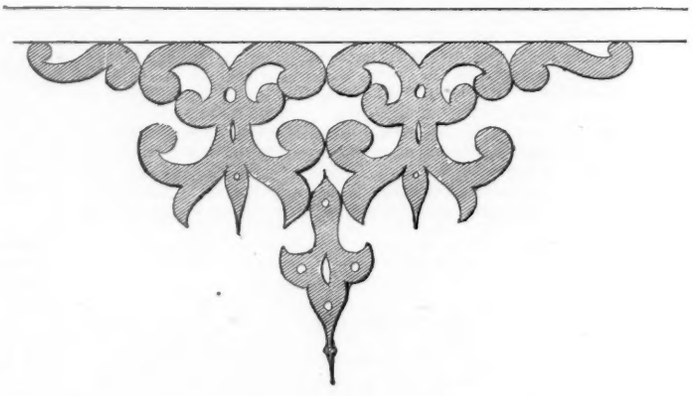


Fig. 451.

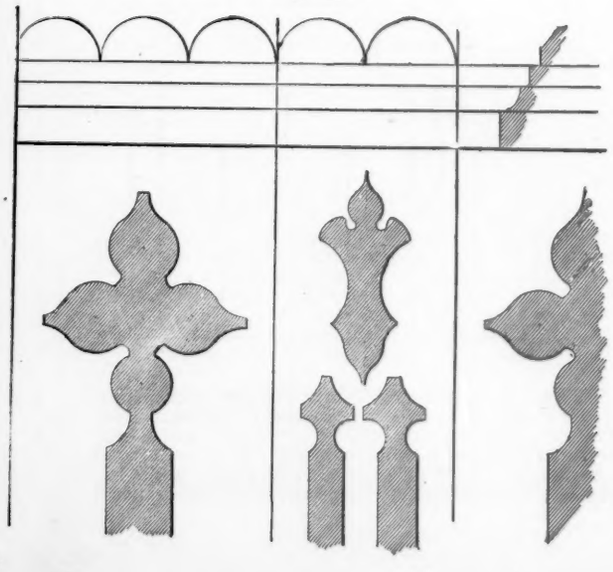


Fig. 453.

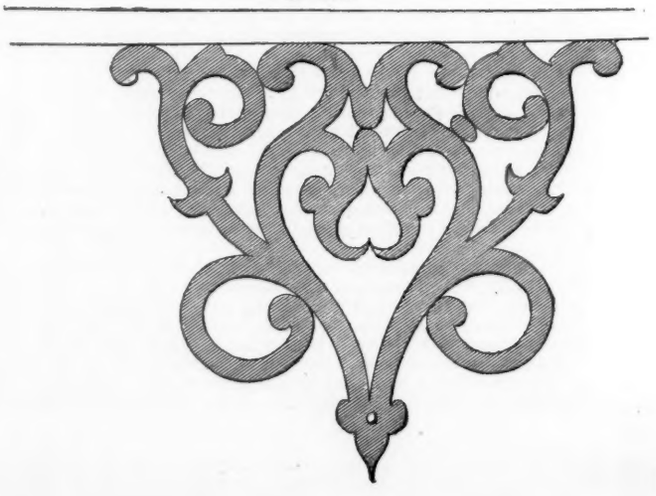


Fig. 458.

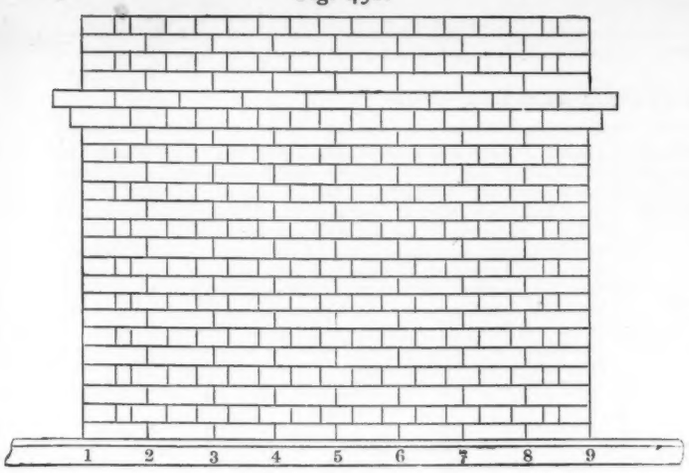


Fig. 454.

Fig. 459.

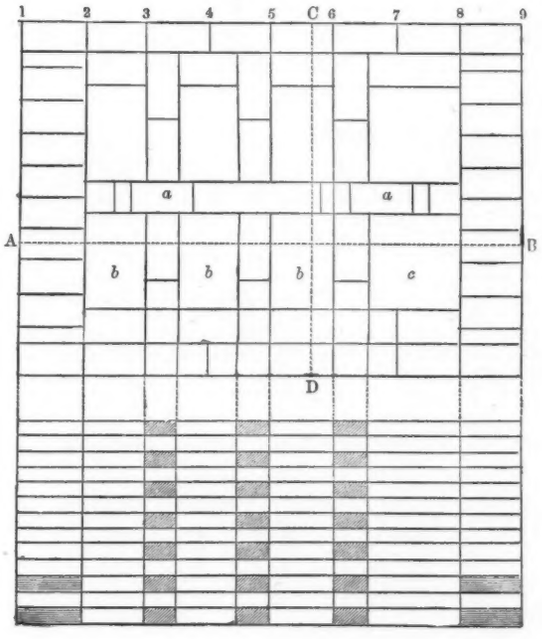


Fig. 455.

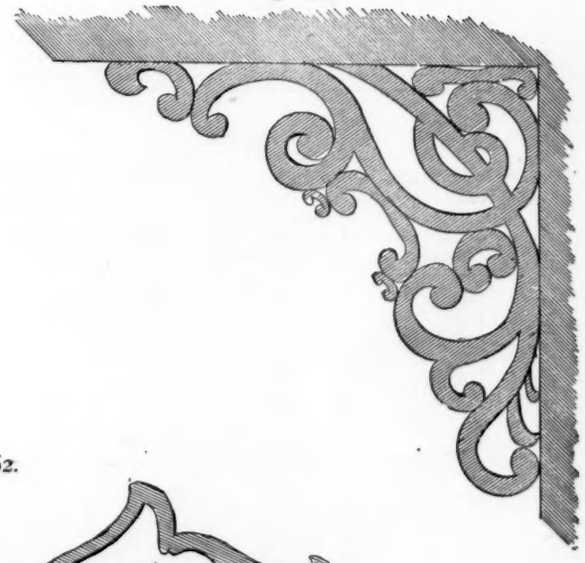
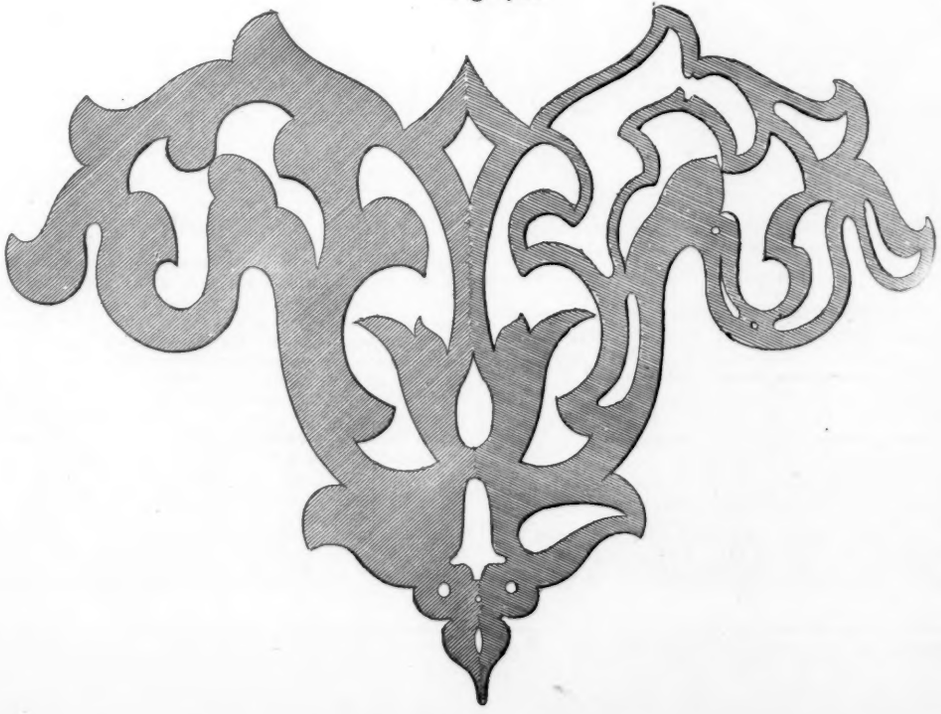


Fig. 462.



parts, one on each side of the central line. Figs. 463 and 464 are other designs for inlaid work.

(90.) **The Elements of Iron Construction.**—Resuming the illustrations on the subject of the joining of irons

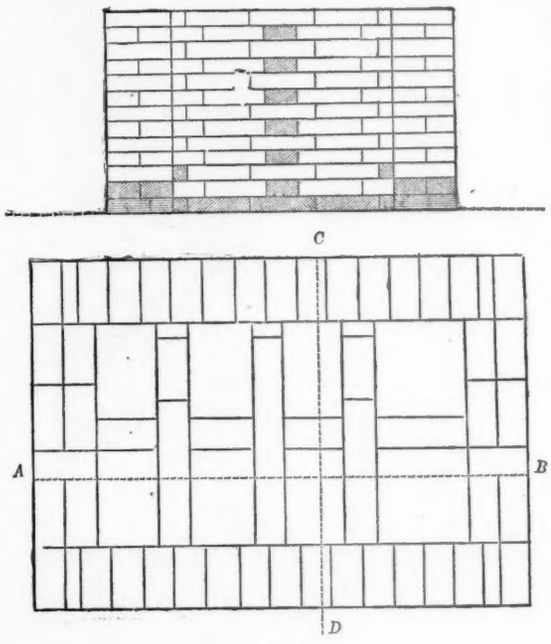


Fig. 460.

forming various structures, we give in fig. 465 a method of effecting the junction of a cross girder *a a*, as, for example, that of a railway bridge, with the main girder *b b b*. The cross girders are placed at intervals, and carry the sleepers and rails, &c., forming the permanent way. The main girders for a

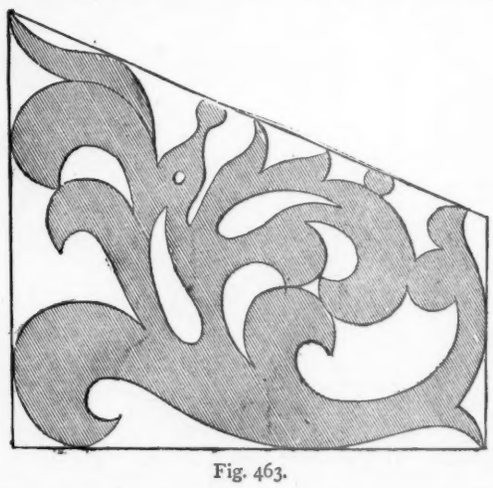


Fig. 463.

double line are generally three in number, as represented by the accompanying diagram in type, *a a* being the outside

girders, *b b* the centre one, *c c* the cross girder carrying the rails, corresponding to *a a* in fig. 465. The main girders may be of the box or tubular form, the lattice girder or the plate girder. The illustration in fig. 465 is of a plate girder, the whole being built up of plates of wrought iron, held together by angle irons, and strengthened by T irons, strengthening plates, &c. The main girder is composed of a flat plate in the centre, as *b b*, fig. 465, strengthened at intervals by vertical angle irons, and by two or more thicknesses of plates as *d d*, *e e*. Fig. 465 is part side elevation of a main girder. Fig. 466 is a cross section of it, in which *a a* is the central "web," or plate, corresponding to *b b* in fig. 465: *b b*, *c c*, the bottom plates corresponding to *d d*, *e e*, in fig. 465; *d d*, the angle irons, corresponding to *c c*, *f f*, in fig. 465. The bottom plates are secured to the web *a a*, fig. 466, by the angle irons *d d*, corresponding to *g* in fig. 465; in fig. 466 *e e* is the end plate with which the inner girder is

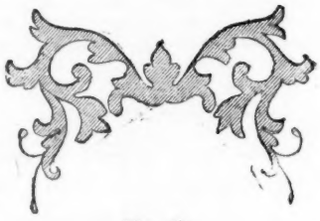


Fig. 464.

finished—see this at *a a* in sectional plan in fig. 469. In fig. 466 the cross girder corresponding to *a a* in fig. 465 is shown at *f f*. This cross girder is strengthened at intervals by vertical T irons, as *a a*, fig. 467, in which *b b* is part of the cross girder in side elevation; *c c* the bottom plate of main girder. In fig. 468 we give part sectional plan of the bottom plate and web which support the cross girders. The cross girders (one on each side of the centre girder) are at *a a*, *a a*, and correspond to *a a*, fig. 465, and *f f*, *f*, in fig. 466; the part seen in fig. 468 being the top of the plate *h h*, fig. 465, with its double row of rivets. In fig. 468, *b b* is the central web or plate corresponding to *b b* in fig. 465, and *a a* in fig. 466: *c c* the central web of the strengthening piece *f f*; *d d* the angle irons connecting them to the bottom plate *e e*, corresponding to the angle irons *i i* in fig. 465;

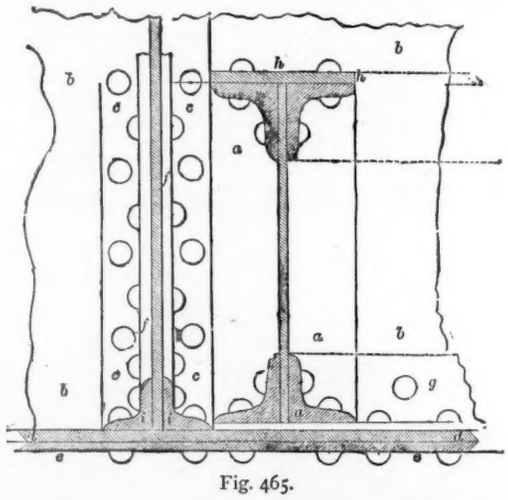


Fig. 465.

f f the angle irons corresponding to angle iron *d d* in fig. 466. In fig. 469 we give the sectional plan of the end of the main girder, which is finished by a vertical plate *a a*, secured to the central web *b b* corresponding to *a a*, in fig. 466, by the angle irons *c c*; and strengthened at the outside by other angle irons, *d d*; *e e* bottom plate corresponding to *e e* in fig. 468; *f f* angle iron, as *f f* in fig. 468. In fig. 470 we give front plan of the top of main girder, showing the chain rivetting; *a a* is top plate of cross girder *a a* in figs. 465 and 466. In fig. 471 we give cross section of the top of main girder, in which the web in central plate, *a a*, corresponds to *a a* in fig. 466; *b b*, the angle irons corresponding to *g g* in fig. 466. *c c* the angle irons of end plate corresponding to *d d* fig. 469, and *e e e*, fig. 466. In addition to these angle irons as *d d*, fig. 471, are placed at the outside of the end plate, and rivetted to the top plates *e e f f*. In the drawing to the left the side elevation is shown, *a a* the central web by sides of angle now *d*, in drawing to the right hand. In place of ver-

tical strengthening pieces of angle iron as in fig. 465 at *c c*, strengthening pieces of T iron are shown at *c c* fig. 471 on the left hand, these T irons being used at certain intervals along with the angle irons, as at *c c* fig. 466; in fig. 471 *d* is the section of *c c*. In fig. 472 we give section of the lower part of a wrought-iron plate girder in which there are three rows of plates *a b' c'*; the central web plate, *b b*, is secured to these by the angle iron rivetted to both web and bottom plates. *d d* are the edges of flat vertical strengthening pieces shown at *d d* in fig. 473 (side elevation of fig. 472)

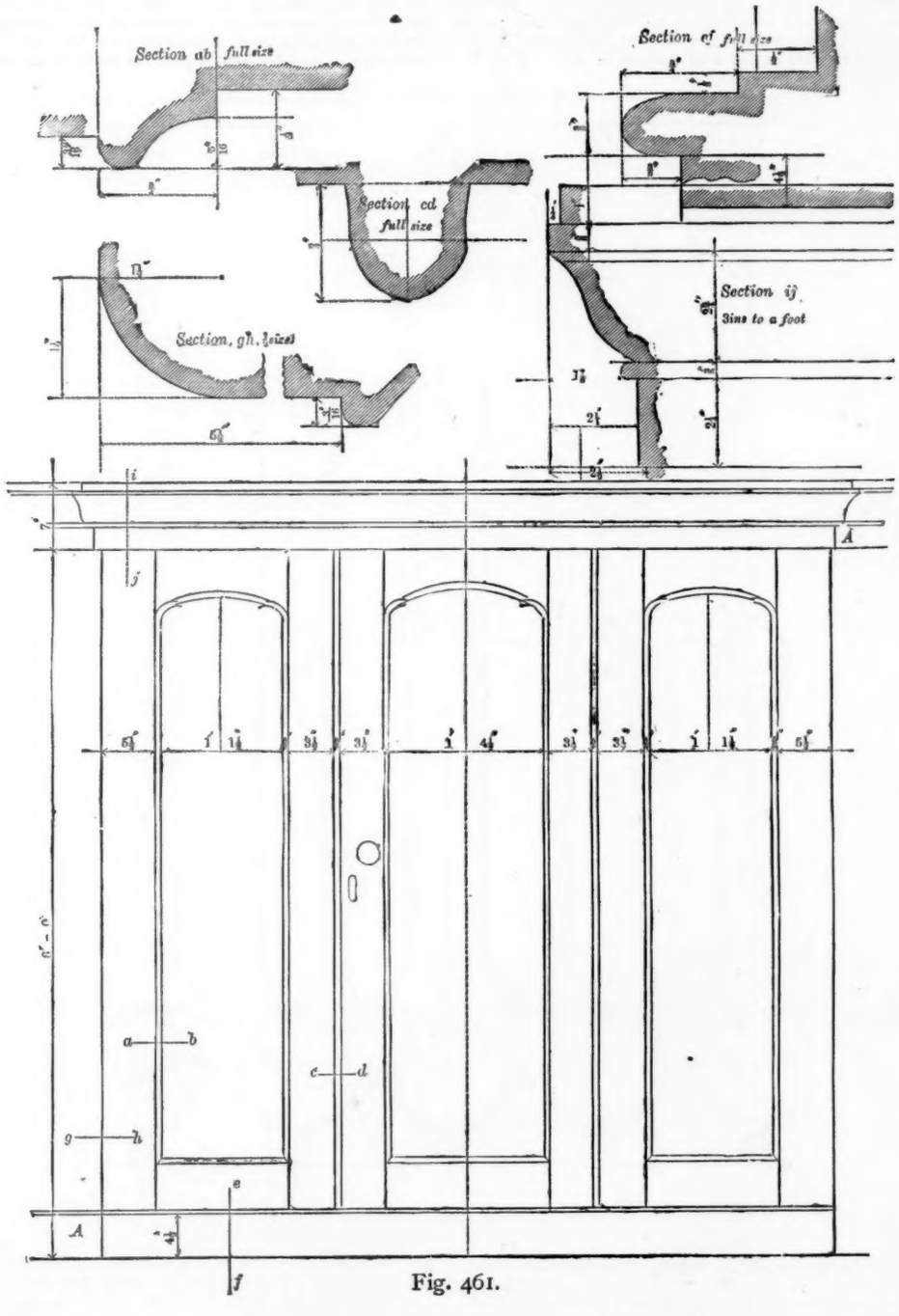


Fig. 461.

Sub-section.—Ornamental Work in Cast and Wrought Iron.—In fig. 474 we give a design for a simple railing, and in fig. 475 the bottom part (top is similar only reversed in position) of a cast-iron balustrade.

(91.) **Elementary Lessons in Drawing.—Section A. Projection as Applied to the Preparation of Constructive Drawings.**—In note No. 50 we gave a few illustrations on this subject, and explained the meaning of the terms plan, elevation, and section, and how these were related to each other in the same plane of projection; the rays, if we may use the term, or points of the various objects being supposed to proceed from or be looked at from an infinite distance, and thus being "projected," so to say, from the object to the eye of the spectator in *parallel* lines at right angles to the

two planes of projection—the vertical and horizontal. We shall now proceed to show how, by the use of these parallel lines, the various views of objects required in constructive drawing may be obtained, the plane of projection being supposed to exist, and thus simplifying the method made as compared with that already described in note No. 50, in explaining what was meant by the term projection. Thus, suppose we have the plan of a square object as *a b c d*, fig. 476, the diagram being "plan of top" of, say, a block of wood or a box, the depth from top to bottom, or height when standing on its base, being equal to the line *e f*. The elevation of the side looking at *a b c d* in the direction of the arrow *g*, is obtained by drawing lines from points *a b*, parallel to one another, and at right angles to *a b*. These lines, if produced, will cut any line *h i*, parallel to *a b*, in the points *h* and *i*. Producing from these perpendicular lines, as *h j*, *i k*, and making these equal to the lines *e f*, and drawing through points *j k*, a line parallel to *a b*, the elevation of side *c d*, will be obtained. The object being square, the elevations of all the sides will be the same as at A; as, for example, the elevation of the side *d b*, looking at it in the direction of the arrow *l*, will be as at B. But the block or box, as in fig. 476, may have one of its sides deeper than the other, as the height *a b*, fig.

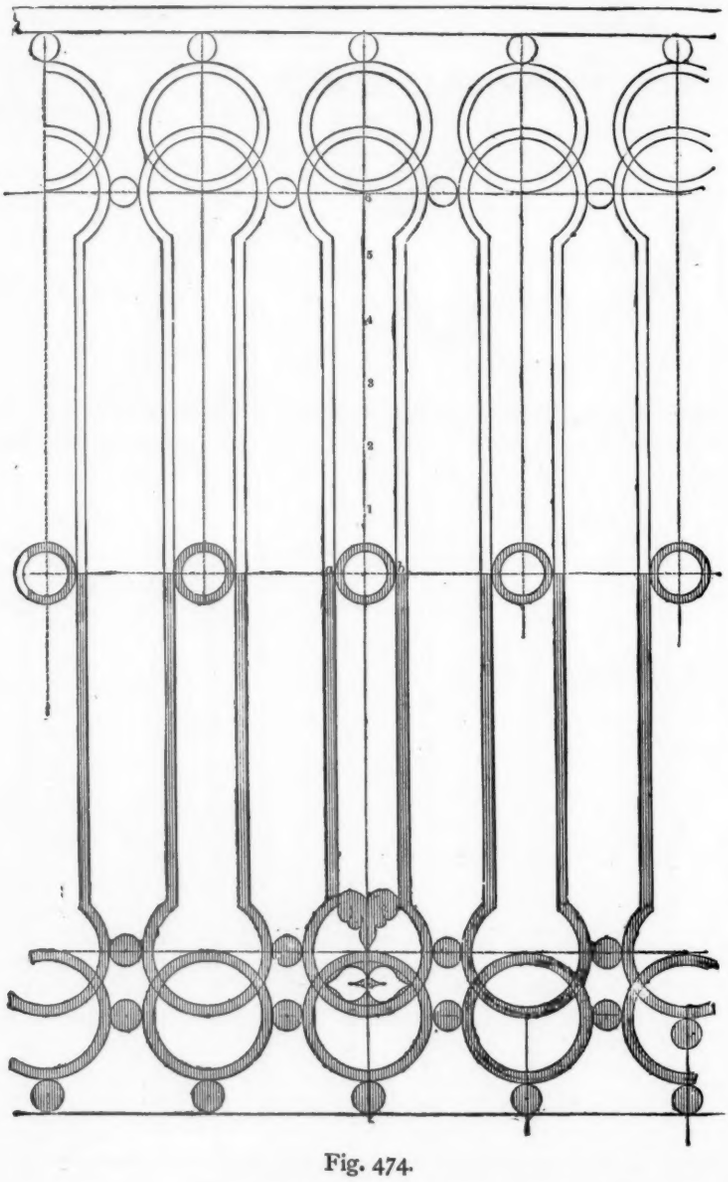


Fig. 474.

477, is greater than the height *c d*. Let *e f g h* be the plan of the block. Draw parallel to *e f* any line as *i j*, and from *h* and *o* draw lines perpendicular to *a b*, cutting line *i j* in the points *k* and *l*, produce the lines to *m* and *n*, and make *k m* equal to *a b*, and *l n* equal to *c d*; join *m n*; *k m n l* is the elevation of the side *e f* of the block *e f g h*, looking in the direction of the arrow *o*. The elevation of the side *f g*, looking in the direction of the arrow *p*, is found thus: Draw parallel to *i j*, from the points *m* and *n*, the lines *n q*, *m r*, cutting perpendiculars drawn from points *s* and *t*, the distance *s t* being equal to *f g*. But the block or box in place of having a top sloping to one side only, as in fig. 477, may slope at its top part on both sides from a central line, as in fig. 478. Let *a b* be the height of the highest part at the centre, and *c d* the height of the block at the sides, and let *e f g h* be the plan of the block, the line *j i* in the centre of its length representing the apex, or line of meeting of the sloping sides. Parallel to *e f*, draw a line *k l*, and cut this in the points *m n* and *o*, by the line *h e*, *j i*, and *f g* produced, and extending indefinitely above *k l*. Make the perpendicular *m q*, *o r* each equal to the height of the side *c d*; and the perpendicular *n p* equal to *a b*. Join *q p*, *p r*. This will finish the "end elevation" of *e f* looking in the direction of arrow *s*. The side elevation *f*, looking in the direction of arrow *t*, is produced by drawing from points *p* and *r*, parallel to *k l*, lines *p u*, *r v*, these cutting

Fig. 466.

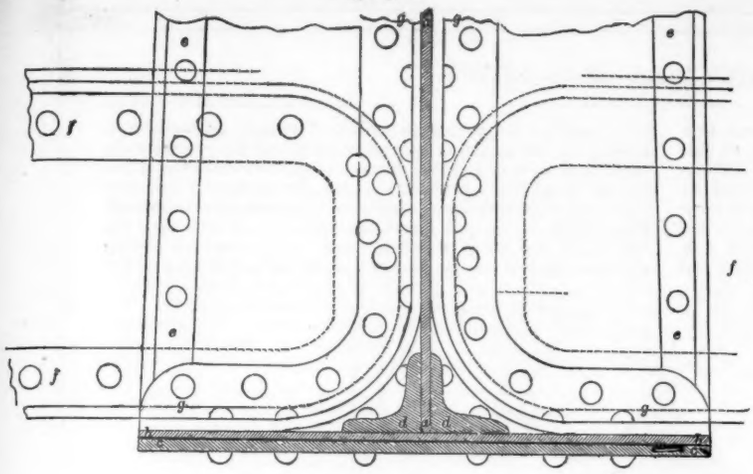


Fig. 467.

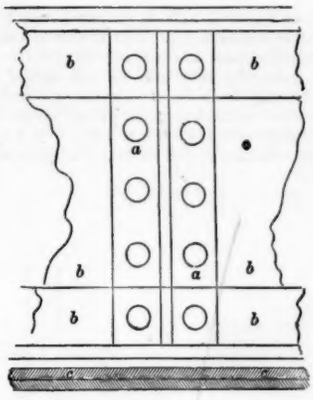


Fig. 468.

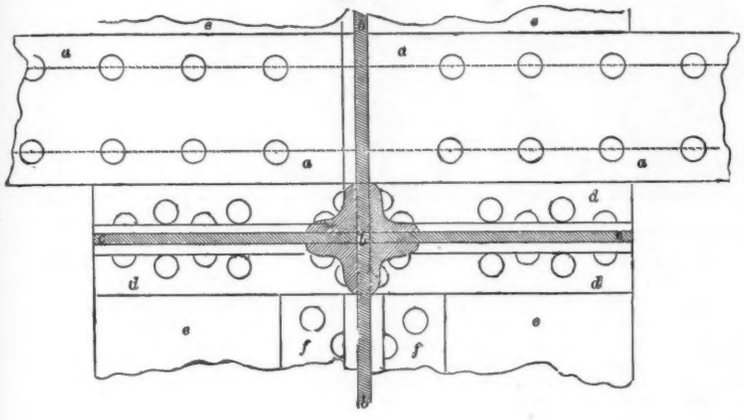


Fig. 469.

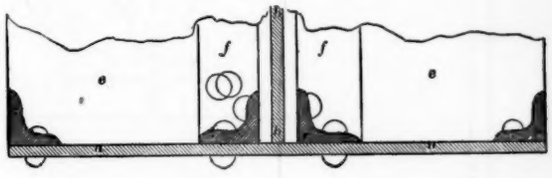


Fig. 470.

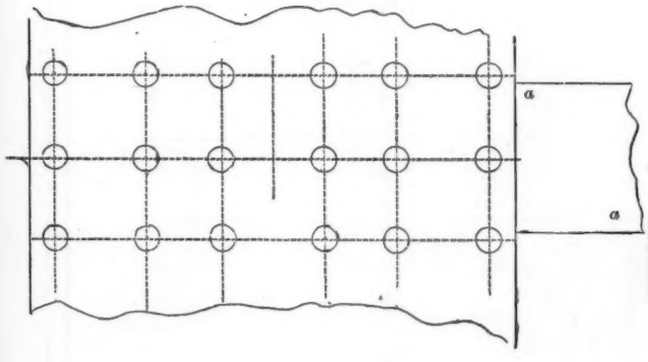


Fig. 472.

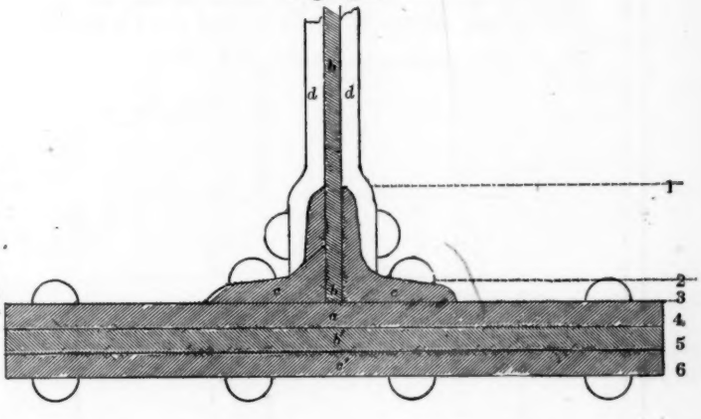


Fig. 471.

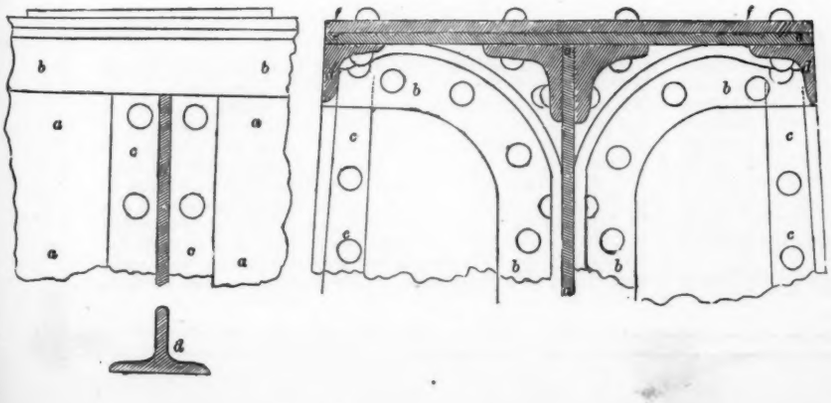
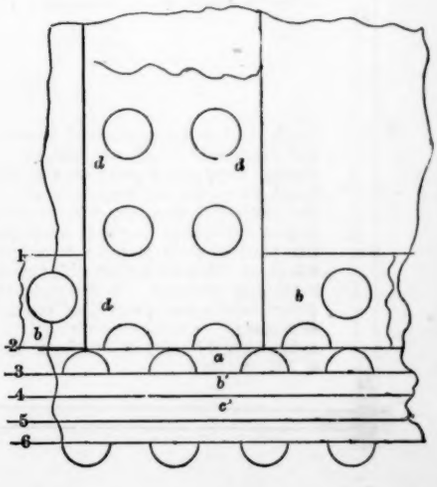


Fig. 473.



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lines from *w* and *x*, perpendicularly to *k l*, the distance *w x* being equal to *f g*. But if the block had sloping ends as well as sides, and of the same height, the side elevation of *f g* (looking in the direction of the arrow *t*) would be produced by drawing lines from the points *f* and *g* to 1 and 2, and from *y* and *z*—these being the points where the sloping ends meet the central line *i j*—other lines, 2 3, 2 4, these cutting a line 5 6, parallel to *f g*, and making the perpendiculars, 7 3, 8 4, each equal to *a b*, and 5 1, 6 2, each equal to *c d*. The end elevation of this, looking in the direction of the arrow *s*, will be precisely the same, and obtained in the same way as end elevation *m n o*. But the block might have the top with sloping surfaces on both sides and ends, and these meeting in a flat space at the top, the plan would be as at *a b c d*, fig. 479, *e f g h* being the flat space, *g e d h* being a sloping end, *c g f b* being a sloping side, the point or line of junction at the corner being *g c*, *h d*,

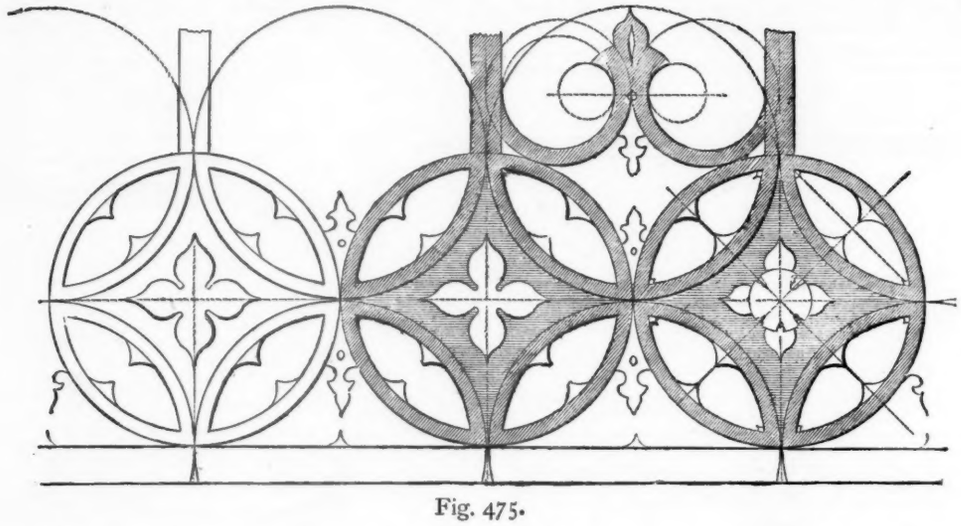


Fig. 475.

a e, and *f b*. Let *i j* be the height of the flat space, and *i k* that of the sides and ends. Proceed as in last diagram at 5 6, 2 1, in order to find the side elevation A of side *b c* looking in the direction of arrow *b*, and from which the end elevation B—*f c d*, looking in direction of arrow *m*, will be produced as before, by drawing lines parallel to *a d*, from the points in A to B. Half only of the end elevation is given, the centre line being *n n*; the point *o* being obtained by cutting off from *p* to *q* a distance equal to *r s* in *A*. Fig. C shows the end elevation, looking in the direction of the arrow. Any peculiarity in the sides of the block may be shown in the elevation; thus, in *u* a square hole or aperture, as *a*, is shown, and in *c* a circular one. The positions of these can at once be defined by measurements from any given point. These diagrams, simple as they are, not only convey a notion of projection as applied in practice, but they will suggest to the reader connected with building, methods of drawing

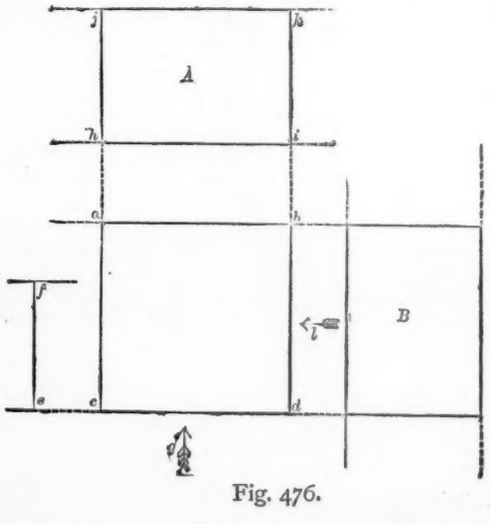


Fig. 476.

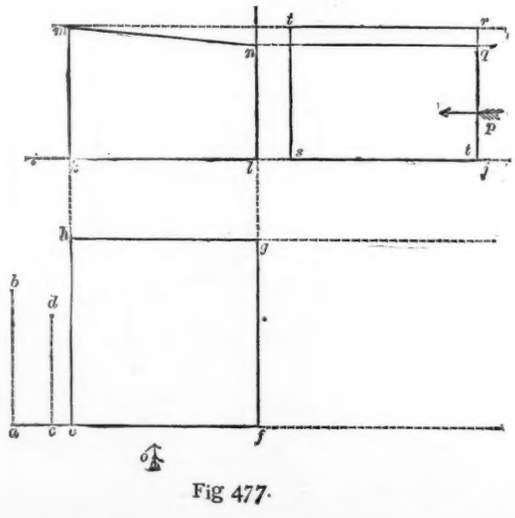


Fig 477.

block plans and elevations of houses, with "gable," and hipped and "pavilion" roofs. It will be obvious also that an interchange, so to say, of methods may be made; thus, the elevation being given, the plans may be obtained, and so on. Pursuing the subject further—for the student cannot have too clear an idea of the various methods adopted—we give, in fig. 480, at A, the plan of what may be considered the "block plan" of a house, of which the height of the central part is equal to *a b*, and *c d* that of the wings. B is the elevation of the side looking in direction of arrow *e*, and C of the side looking in the direction of arrow *f*.

We have hitherto confined our illustrations to objects having a rectangular or square plan; we now show how projections of bodies otherwise formed can be obtained. The elevation of a block circular in section or plan, and of height equal to *a b*, fig. 481, is simply a rectangle, of which the breadth *c d* is equal to the diameter of the circle *f g*, and the height equal to *a b*; the lines being obtained by producing the lines *f c*, *g d*, from the points *f g* the extremities of the diameter of circle, cutting a line *c d* parallel to *f g*, making *d e* equal to *a b*. In the same figure a hexagon, B, is given in plan; an elevation of a block of this shape, and the height of which is equal to *h i*, is obtained thus:—There are obviously two views of this unlike each other, the one is seen in the direction of the arrow *j*,

which is shown at C; the other is seen in the direction of the arrow *k*, shown in fig. D. To obtain view C, draw any line, *l m*, parallel to *n o*, joining the opposite angles; from points *n o p q* draw perpendicular lines, *n l*, *p r*, *q s*, *o m* at right angles to *n o*, cutting the line *l m* in points *l m*, *r s*, with the distance *h i* cut the line *r t*, in *t*, and through *t* draw a line parallel to *l m*. To obtain view D, produce lines from points *u*, *n*, and *k*, parallel to the line *n o*, cutting the line *w v*, make the three lines equal to *c h* as *v x*, and through *x* draw a line parallel to *w v*. In fig. 482 we give in A the plan of an octagonal block, the height of which is equal to the line *a b*. On inspection it will be seen that one elevation, as B, will only be required if looked at in front of the four points, *d e f g*, and at right angles to the lines joining these in the direction of the arrow, and this because all the sides and all the angles are equal measured from these points. The other view is an angular one on the line *i j*, looked at in the direction of the arrow *k* at right angles to *i j*; this view being shown at C. To obtain the view B, lines are produced from the points *f i d*, *j* and *g*, parallel to *e d*, and cutting a line *l m* as shown, *m n* being made equal to *a b*, and a line drawn through *n* parallel to *l m*. To obtain the elevation in C, draw the line *i j*, and at right angles to it from the points *e*, *o*, and *g*, draw other lines cutting *i j* in *p*, *q*, and *r*. Draw any line, *s t*, and from any point thereon, as *s*, set off to *v* the distance *i p* from line *i j* in A. Make *s w* equal to *i q*, and *s x* equal to *i r*, and *s t* equal to *i j*; from *s*, *v*, *w*, *x*, and *t* draw

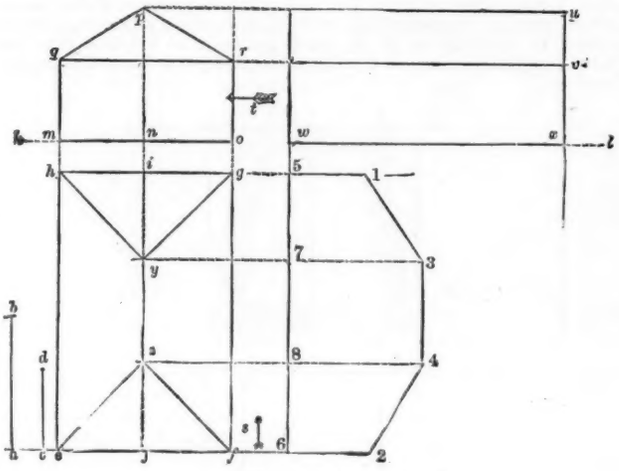


Fig. 478.

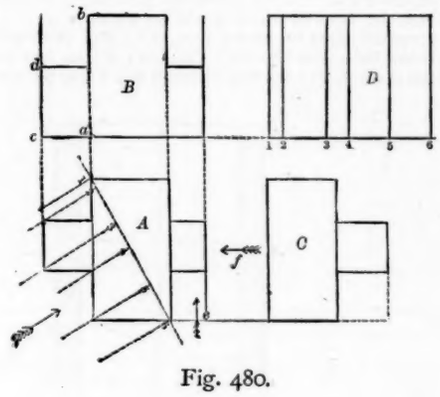


Fig. 480.

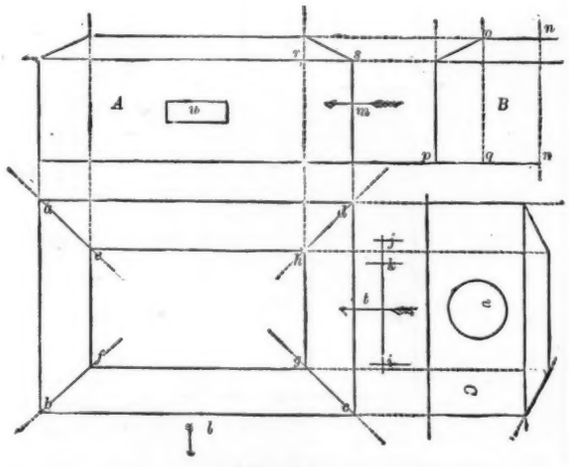


Fig. 479.

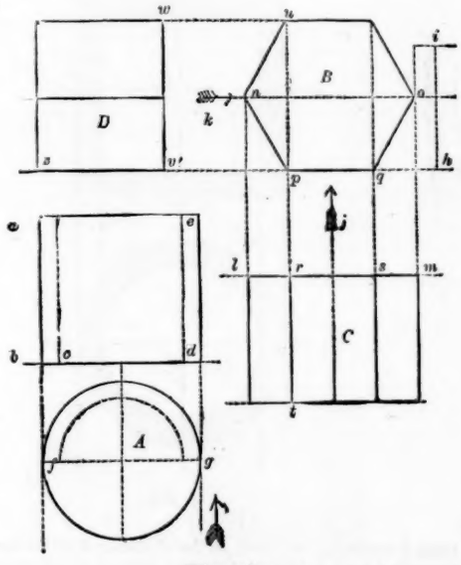


Fig. 481.

lines perpendicular to *s t*, and cut them by a line parallel to *s t*, drawn through the point *y*, as *y z*, *t y* being made equal to *a b*. The view D, in fig. 480, on the angular line 1 6 in A, is obtained in the same manner, as shown by the points 1, 2, 3, 4, 5 and 6. Another and quicker method of obtaining the view C in fig. 482 is shown in fig. 483, in which the line *a b* corresponds to line *i j* in fig. 482. Draw any line, *c d*, parallel to the horizon *a*, at right angles to the perpendicular, *f g*, fig. 482; produce the line *b a* till it cuts *d c* in the point *c*; then from point *c* as centre, with the radii, as *c a*, *c e*, *c f*, *c j*, and *c b*, describe arcs, cutting the line *d b c* in the points *h*, *i*, *j*, *k*, and *d*, from which draw lines perpendicular to *c d*, and make *d l* equal to the line *a b* in fig. 482, and draw *l m* parallel to *c d*. We shall, in another note, draw the reader's attention to the projection of objects which are at angles to the planes of projection, all the lessons hitherto given being connected with objects the lines of which have been parallel to the planes of projection—meanwhile, taking up the subject of "sections," showing their relationship to plans and elevations, and how the measurements of those are useful in giving those of the sections. Take, for example, the case of a cylindrical block, as *f g*, of which, as we have shown in fig 481, the elevation is a rectangle, as at *d e*. But if the cylinder, in place of being solid, was hollow, this hollow being a circular aperture, the diameter of this might be indicated in the plan, as *f g*, fig. 481; the extremities of the diameter of this being produced by lines giving those dotted lines shown at *d e*. In fig. 484, we give at A on the lower side of the diameter *a b*, the half plan of a cylindrical block; and on the upper side half sectional plan taken on the line *c d* in B in same figure. A is what is called a "transverse" or "cross section" on the line *c d* B, or it may be called a "sectional plan." The elevation of A is simply a rectangle *e f g h*, B, the lines *a g*, *b h* being carried up perpen-

dicularly to the diameter *a b* A, the thickness of the sectional part being shown by the lines parallel to *e g*, *f h*. The view in B is what is called a "tranverse vertical section" on the line *a b* in A, or it may be called a "sectional elevation." If the hollow in the cylinder was provided with a plate across it, in the middle of its length, it would be indicated by the lines shown by dots on each side of the line, as *c d* in B. If the sectional elevation was given, the sectional plan in A would be obtained by carrying down the lines *f b*, *e a*, cutting *a b* in *a* and *b*, which would be the diameter of the outer circle, that of the inner one being obtained by producing the sectional lines in B to cut the line *a b*. In practice this production of the lines might be unnecessary, for by drawing a line *a b*, and from any point A, on thus describing a circle, the radius of which would be half the distance *e d*. Or the elevation in B might be that of a square box, the lines of which would be obtained as in C by dropping perpendiculars to cut any line, as *i j*, and produced indefinitely below that, thus bisecting the line *i j* into two equal parts, in the point *k*, and drawing through this a line parallel to *e i*; and

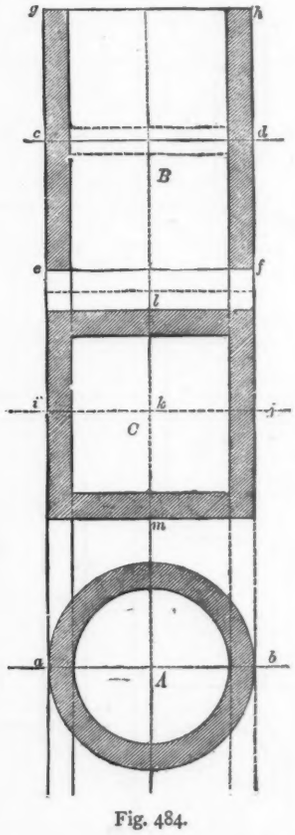


Fig. 484.

from *k* setting off to *l* and *m* the distance *k j*; by drawing lines through *l* and *m*, intersecting the lines *i j*, the outside of the square would be obtained; the thickness of the sectional part being taken from B, and set off from each side of C, and an internal square formed.

In fig. 485 we give *a b c d*, the plan of base of a box, the height of which is equal to *a' b'*, and which is narrower at top than at bottom, as shown at *g h*; this upper figure is a transverse vertical section, on the line *i j*. The plan of top is at *k l m n*; and shows that it is provided with two apertures, *o* and *p*, *o* being shown in section at *g*. The lines of plan of top are obtained by dropping perpendiculars from the points *e* and *f* and *g* and *h*; to *k r s* and *l*, and producing a line to *m n*, making *l n* equal to *c d*. In fig. 486, we give in A part elevation of the arm of a wheel, or a cast-iron brace or stud of a roof, and in B section of same on the line in *b* in A; the breadth of the cross part of B is equal to *c d*, and the thickness equal to width of part ("feathers" or "rib.") The junction of the two ribs may be made square, as at *h h*, angular as at *g*, or rounded as at *f*, which is the usual plan adopted. In fig. 487, we give at A, elevation of two pieces of timber, *a* and *b*, bolted together by a screw bolt and nut; and at B section of same, showing the diameter of bolt *c c*, with "nut" *d*, and "head" *e*; *f* is plan of nut showing that it is square.

(92.) **On the Describing of Mouldings.**—Having in previous notes illustrated the method of describing the mouldings known as "classical," we now give these mouldings in "assemblage," choosing for this purpose the bases of what we called the "five orders," these are first: "The Tuscan," at fig. 488; "The Doric," at fig. 489; "The Ionic," at fig. 490; "The Corinthian," at fig. 491, and the "Composite," at fig. 492. These are made up of a combination of the mouldings we have already described, and their "heights" (in the vertical centre line of each style) and "projections" from the centre line, are all taken from a "scale" which is provided for each order, and is made as follows: The diameter of the shaft A, fig. 488, immediately above the base, B, before it (the shaft) begins to diminish, as all the shafts are wider at the base than the capital, is taken as the line *e f*, fig. 488, and this is divided into

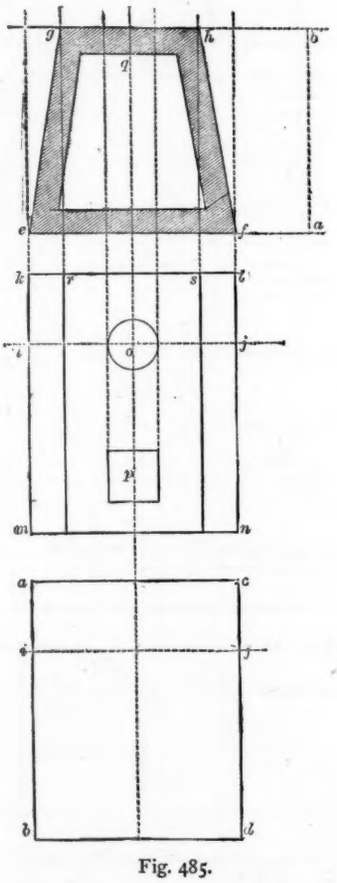


Fig. 485.

sixty equal parts, each part being called a "minute," and half of the diameter, or thirty minutes, a "module;" the "projections" of the mouldings are measured from the centre line *a b*; as the plinth *c d* from *a* to *c*, which gives 42; and the "heights" also are measured from the centre line, as from *a* to *g*, which gives 13 minutes. In our next note under this heading, we propose giving the assemblage of mouldings met with in entablatures, pedestals, &c., &c.

Gothic mouldings are materially different from the classical mouldings, which, as we have shown, have their outlines formed by curves which are either parts of ellipses in the case of Grecian, or of arcs of circles in the case of the Roman mouldings, and are in all cases defined by certain rules or methods of construction as to the nature and number of these curves; but in the case of Gothic mouldings, although classical mouldings may be met with, still they are modified and changed, not so much by any rule or apparent rule of construction, as by the taste, skill or caprice of the designer, while other mouldings are met with which have no parallel in classical work of this kind, and belong peculiarly to Gothic architecture. Still each style or period—and

Fig. 482.

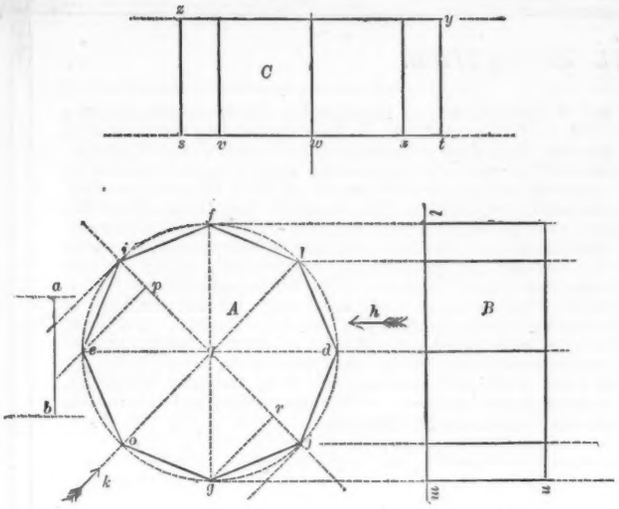


Fig. 483.

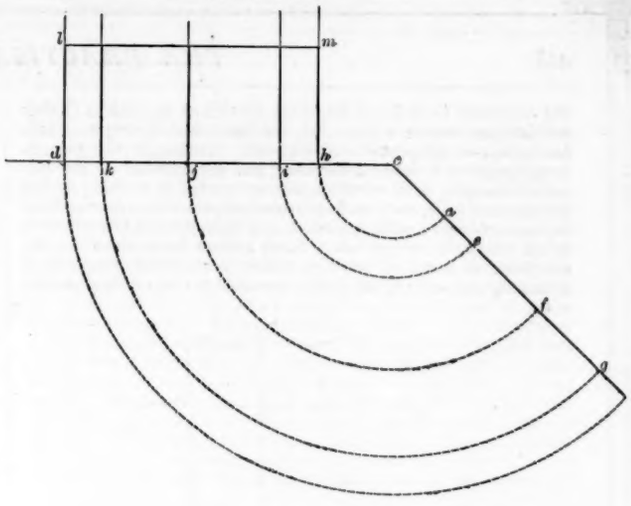


Fig. 488.

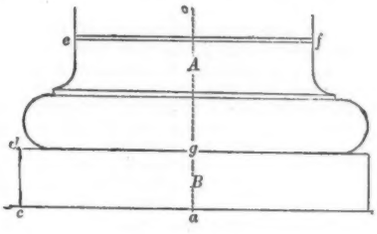


Fig. 489.

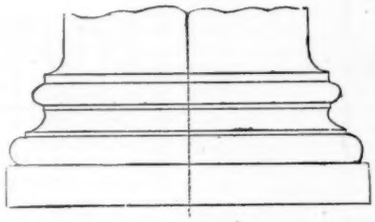


Fig. 490.

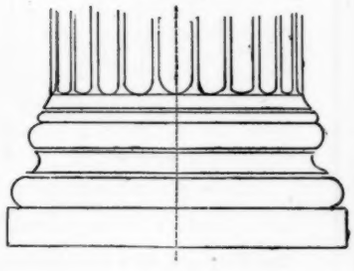


Fig. 491.

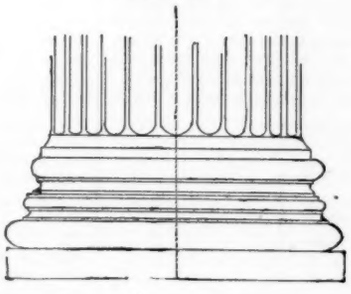


Fig. 492.

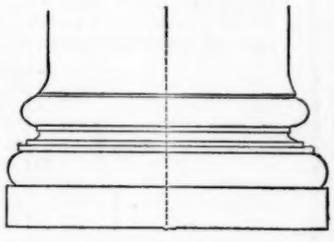


Fig. 493.

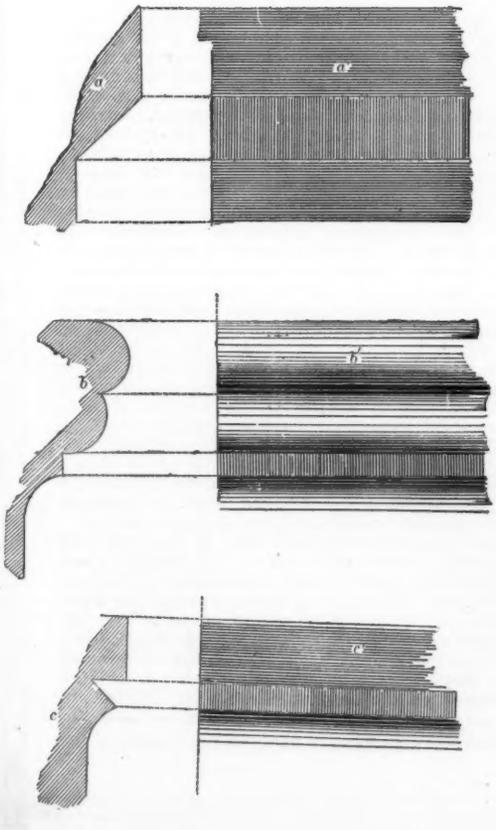
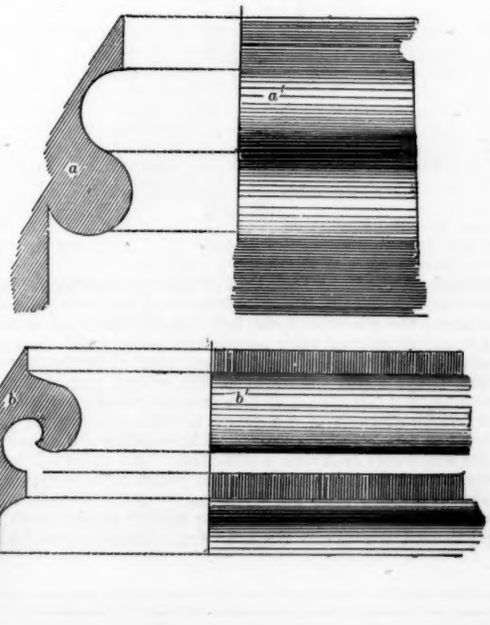


Fig. 494.



XUM

the last term is perhaps the most correct as applied to Gothic architecture—as each prevailed, and flourished during a certain period—can be pretty well defined. Although the periods overlapped each other sometimes, the peculiarities of the last period marking those of that which succeeded it, forming a kind of transition style, each has its own marked peculiarities exemplified in its mouldings; although some run through and are met with in all the styles or periods. Some writers have argued for the existence of a set of rules or rather geometrical methods of obtaining the outlines of Gothic mouldings; but if they existed

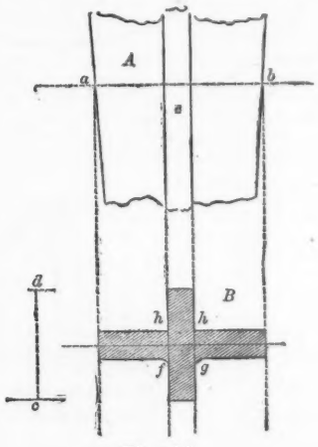


Fig. 486.

they have not been handed down to us, and, on the whole, a careful review of the subject will induce us to believe that no such methodical systems prevailed as characterize the classical mouldings, but that in Gothic architecture as in the general design of the building, each architect or builder left the impress of his own skill or caprice upon it; so also in the case of the minor details with which that design was embellished and enriched. While, therefore, by a careful collation of a wide varietyof mouldings, we, the moderns, may endeavour to deduce from them a

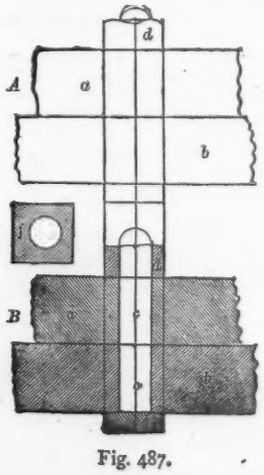


Fig. 487.

systematic method—and we believe this has been attempted by one French architect, if not by others—of constructing Gothic mouldings, there is little doubt but that the mediæval architects and builders designed their mouldings as they did the enrichments by which they were so often embellished by the aid of the hand and eye alone. Many examples indeed give rise to the conjecture that the mason, as he was cutting and carving out his work, designed some of the details as he went along, for much, very much was left to the taste and knowledge of the workman whose skill in his craft was established. The styles or periods of Gothic architecture as it flourished in this country, are usually divided into four; first, the "Norman," which flourished from the date of the Conquest to about the middle of the twelfth century; second, the "Early English," from the latter period to the end of the thirteenth or beginning of the fourteenth century; third, the "Decorated," which flourished during the fourteenth century. This style is divided into two periods, the "Early Decorated," in which the curves of the window tracing were chiefly composed of geometrical curves, as arcs of circles, trefoils, quatrefoils, &c., hence called sometimes the "Geometrical Decorated;" the other period being the "Curvilinear Decorated," so called from the curves of the tracing being usually drawn by the eye, and not geometrically constructed; sometimes also called the "Later Decorated." The fourth period of the English Gothic is known as the "Perpendicular." Of the mouldings of these four periods, we give rough outline sketches. In fig. 493, we give in *a b* and *c* three sectional sketches of "Norman" mouldings, *a' b'* and *c'* being elevations of the same; in fig. 494 at *a* and *b* sectional sketches of "Early English" mouldings, *a'* and *b'* being elevations. Other illustrations will be given in our next note under this heading.

THE MANUFACTURE OF IRON AND STEEL RAILS.

By John B. Pearse, Superintendent of Pennsylvania Steel Works.[1]

IN order to get an idea as to the strength of steel rails, it will be well to review the tests to which iron rails have been subjected. In England, Mr. Ashcroft found that the best 80 lb. rails broke under a 300 lb. weight, falling 15 ft. In Germany, the Society of Railway Managers determined on and have long applied a test of 1,000 lbs. falling 10½ ft., as the standard which all first-class iron rails must reach. In this country no inspection or test is applied, but tests made show that iron rails, from our most reliable makers, break under a 6 foot fall of a 1,500 lb. drop as an extreme test, most of those tested breaking under a far less test; some breaking with less than a 3 foot fall of the same weight.

Everywhere where steel has been used, engineers have come to the conclusion that some test is required to show the regularity and strength of the product. As compared with iron, the tests which steel will stand are wonderful. After numerous experiments, partially based on the experience of the rail-mill at Graz, belonging to the Southern Railway of Austria, the Society of German Railway Managers fixed upon a test of 2,000 lbs. falling 13½ ft. They found that this test represented the steel which suited their necessities, and also found that with steel of otherwise average purity, this test represented about one-half per cent. of carbon, and made it a rule to take no steel containing under three-tenths of a per cent. of carbon, because it was too soft. They expressed a hope that a harder steel could soon be made tough enough to stand the same test. In England, a test was adopted of 2,240 lbs., falling 15 to 17 ft. on the rail on heavy bearings. This test has been found satisfactory under heavy traffic on average road-beds, and has been invariably retained by English makers, and adopted by American makers. It is an expeditious practical way of ascertaining the qualities of the rail. Experiment in Germany and experience in England pointed out the test corresponding to the proper grade of steel, and the test adopted has been considered the most practical one. The jar from a moderate weight (2,240 pounds), falling from a great height, is more sudden than that imparted by a heavy weight falling a small distance, and better adapted to exhibit the toughness of the rail. This latter is the object had in view in all tests, as it would take far too long a time to determine the quality of rails by a treatment approximately similar to that received in the track. An objection of some force has been urged against the English method of obtaining test pieces. They take one rail from each day's rolling, to indicate the quality of the rest. In this way their test becomes a matter of chance, and nothing they have yet done removed this character. Our American practice has been to test every charge, thereby insuring beyond doubt the quality of the rails.

After a short experience with steel rails, it was found that their homogeneity is their distinguishing characteristic; but they unite entire homogeneity with considerable hardness as compared with iron. There are no layers to peel off, no welds to open out, the ends of the rails do not broom out as iron rails do, and the head wears uniformly along its whole length. Not only is the single rail entirely homogeneous, but all the rails made from a single charge have exactly the same qualities. Many experiments on the steel at Seraing, in Belgium, in

[1] Transactions of the American Institute of Mining Engineers.

Austria, and in this country, before and after its conversion into rails, show this to be a fact.

But the hardness is a most important point as regards wear. Some first-rate English rails have been found too soft for roads with heavy traffic. Therefore, a rail is wanted which will be hard enough to stand abrasion and wear, but strong enough to stand all the strains to which it is liable. The railroad engineer's idea of hardness is that quality which imparts durability without brittleness. Hardness is sometimes erroneously associated with brittleness because some hard bodies are brittle, but in steel brittleness arises from causes entirely different from those which produce hardness. The steelmaker's idea of hardness is a composite one—one that results from considering the effects of physical structure or grain of the steel, and the effects of carbon, phosphorus, and manganese. The effects produced by the presence of these elements far exceed any brought about by change of physical structure. Phosphorus and manganese occasion brittleness, while carbon in excess is seldom present, as the processes through which the rail passes have a constant tendency to reduce it. The state in which carbon is present in the rail is, however, remarkably influenced by mechanical treatment and the resulting physical structure. Those modes of reduction which work quickly and forcibly exert a strong influence to retain the carbon in a combined state, while the slower methods, on the contrary, permit some of the carbon to separate as graphite. These facts have been observed by Grüner and Caron, and have been corroborated in Austrian practice, as the following analyses of steel will show :

(*a*) Steel made for heads of steel rails at Graz, and rolled into shape without hammering :

Combined carbon	03·8
Graphite	0·65
Silicium	0·05
Manganese	0·07
Sulphur	0·05
Copper	0·08
Iron	98·57
	99·85

(*b*) Steel made at Neuberg and hammered into shape :

Combined carbon	0·234
Graphite	none
Silicium	00·330
Phosphorus	00·440
Sulphur	traces
Manganese	0·139
Copper	0·105
Iron	99·445
	100·000

Both these steels were soft Bessemer steel, and from observations I made at the two works on the respective quality of their metal, I see no reason to doubt their correctness. A remarkable point in the matter is that the iron at Neuberg was much more graphitic than that used at Graz. At Neuberg they tapped direct from the blast furnace, and their "blows" averaged about thirty minutes, some running up to fifty minutes. At Graz they remelted their iron in an air furnace, and their "blows" were much shorter. The iron each works used was then of substantially the same character, made by charcoal from spathic ore. Neuberg made its own iron, while Graz bought its own iron largely from Mariazell and Eisenerz, furnaces not far from Neuberg.

Now, at the Pennsylvania Steel Works, we have a quite graphitic mixture for conversion, but we find scarcely any graphite at all in the rails—in fact, none. Out of many tests we have only one, an apparently abnormal one, in which the graphite amounted to 0·08 per cent., it being generally present in too small quantities to be estimated.

Speaking within the limits of steel manufacture, it is safe to say that brittleness has nothing to do with the mechanical treatment, yet by this treatment the state of the carbon may be controlled and the specific gravity and consequent density of the steel increased. Rails are brittle when too cold-short from the presence of phosphorus and manganese. The proper proportion of the former forms the most delicate point in steel-making, and must always be kept within safe limits. No good steel rail has ever yet been made with more than one-fifth of one per cent. of phosphorus, and half that is considered too much by Bessemer. In regard to manganese, our experience is not yet fully ripe. Its action, however, is far less dangerous than that of phosphorus, and in small quantities is beneficial.

We have thus a definite idea of the important qualities of steel rails and the proper tests to show their uniformity. The tests made on the steel preclude possibility of brittle steel being used, and it is evident that those methods of reduction which unite the greatest hardness with the necessary strength are to be preferred. In general terms, a steel rail is wanted to last a lifetime, and to be strong enough to stand all accidents of wear.

Rail-making begins with the Bessemer ingot. This is a block of highly crystalline metal, the tensile strength of which is low, and which contains some blow-holes or bubbles formed by the carbonic oxide retained by the liquid steel. The inner surface of these bubbles is generally oxidized, and they are apt to be more numerous near the surface of the ingot.

The first steel rails made ten years ago were treated like cast-steel. Until 1863 they were made from ingots seven to eight in. square, and four and a half ft. long, in four heats. In the first two heats the ingot was hammered down to size, one end at a time, and swaged in dies to the shape of the first pass of the rolls. Then the bloom, by this time eight ft. long, was rolled in two heats through twelve passes into a finished rail.

This process was excessively crude, wasting everything a steel-maker cares to save ; and as the rails were found deficient and their weak points tested, it was found that the small size of the ingots and the little work done on them caused a great number of imperfect rails and a very poor quality in the steel. At this time the expressions of want of confidence in Bessemer steel took shape. We have now, however, surmounted all difficulties, and produced a reliable uniform quality of steel in enormous quantities, considered in the light of former capabilities of production. We now use very large ingots, which necessitate thrice the work formerly applied. In 1867 the ingots were raised in England to ten in. square, and in 1870 to twelve in. square, which is the size in general use. In America we have had exactly the English experience with small ingots, the efforts to use them to advantage having entirely failed.

Seeing, then, that large ingots weighing three quarters of a ton, and making two rails, have been found necessary, it has become a question as to what mode of working them up gives the best results. I think that hammering furnishes the preferable product, and my present experience goes to justify the opinion. Rolling is preferred by some makers because it is thought cheaper, but I think the better wear of a hammered rail is a strong point in its favour. Rolled rails are generally softer than hammered rails, for the reason I have given—namely, because their carbon is apt to be partially separated as graphite, and their density is less.

There have been, in the history of iron metallurgy, two noted contests between rolling and hammering, in one of which the hammer came off victorious, in the other the rolls. I refer to the manufacture of hammered iron and to that of armour plates. Hammered iron is a necessity for smith's work, and the qualities imparted to it by continued piling and hammering are wonderful as compared with ordinary iron. The reputation of the Low-Moor and Yorkshire iron tires and plates is world-wide, and the steel tire had in the Low-Moor tire for some time a formidable competitor. In this case the benefits are produced by a better texture of the iron, and greater ductility developed by the work done. The cinder is thoroughly expelled in the blooming and first piling, and may be left out of the question. In the other case the object was to get as soft and wax-like an armour-plate as was consistent with the strength necessary to resist the impact of the shot. As the work done by the shot generally used represents in foot-pounds the effect of one (gross) ton falling a mile and a half, it will readily be acknowledged that there is little similarity between the case of an armour-plate and a steel rail, which has to stand a ton weight falling only 17 ft.

In my own experiments on the effects of the two processes, I compared ingots of the same steel with an average area of respectively about 75 and 110 square in., average section, as they were the only moulds I had at the time to compare. I found that the rails made of blooms, hammered from the ingots of the latter section, stood over 100 per cent. more than the rails made direct from the ingot. The bloom was hammered to the size of the ingot, and each rolled in two heats, one of them a wash heat, into the same kind of rails. I tested in this way 31 different charges. Weight used was 2,000 lbs., bearings two ft. apart. The rails from ingots stood 21½ ft. fall of this weight, showing $1\frac{6}{10}$ of an inch deflection without breaking. The rails from the blooms stood a 43 ft. fall of the same weight without breaking, and showed a deflection of $3\frac{9}{10}$ inches. This leaves a surplus of 50 per cent. in favour of the hammered rail, deducting 50 per cent. for amount due to difference of area of ingots. To show the connection, on a manufacturing scale, of these tests with the actual result, I would remark that we made 13,285 rails out of the ingots of 75 square inches average area. Of these there were rejected by the railroad, for insufficient strength, after delivery, 178 rails, or $1\frac{1}{3}$ per cent. Of the larger ingots we

had made up to the fall of 1870, 34,320 rails, and had rejected for all causes, after delivery, only 18 rails, or $\frac{1}{20}$ of one per cent., or a quantity only $\frac{1}{16}$ as large as before.

We therefore continued to hammer, but now use an average section of 150 square inches; doing two-thirds the work under the hammer, and only one-third in the rolls. Our rails thus produced stand a ton weight, falling $17\frac{1}{2}$ ft., and leave an ample margin of reserved strength. We have had recent tests, in which the rail stood what was equivalent to a ton weight falling 70 ft. without breaking, but have not yet got up to the armour-plate standard of a mile and a half. Out of a lot of 1,200 tons of 58 and 60 lb. rails, not a single rail, out of the 439 tests given, broke under a ton weight falling $16\frac{1}{4}$ ft. We have since had many similar series.

The bubbles in the ingots give some trouble in the subsequent working, sometimes occasioning cracks in the ingot requiring to be chipped out. This we do, as we hammer the ingot down, without hindering the hammer in its work. Rolls are apt to laminate these bubbles instead of forcibly compressing them like the hammer, and it sometimes happens that the bubble breaks out on the surface of the bloom, and causes a long streak, where the metal is not sound. These streaks are especially noticeable in the head of the rail. In order to obviate the cracks resulting from these blowholes, a hammer must be associated with the rolls to chip out bad places; and this renders the rolling processes more complicated than it would appear at first sight. I do not see why it is not simpler to do all the work under one tool—namely, the hammer.

The objections to hammering, on the score of cutting sharply into the metal, are not, in my opinion, of weight, as our experience agrees with the English, that you can hardly have too heavy a hammer for steel. We can strike two full blows of a twelve-ton hammer on the same place without deforming or injuring the bloom in any way, or making a mark on it deeper than $\frac{1}{8}$ in. each time. As showing what steel will stand, I will say that I have seen, in Vienna, Haswell's hydraulic press reducing ingots from ten in. thick to two in. at one squeeze, without injuring the steel, which was from Neuberg. It is thus surely idle to talk of a hammer as injuring steel in any way. The stroke of a heavy hammer works uniformly through the bloom, drawing the interior as much as the surface. We want to make a hard and tenacious bloom, and the concentrated blow of a heavy hammer is well adapted to that end. We lose practically nothing in ductility as compared with the rolls, and have ample room within the limits of our strength. The chemical composition controls the brittleness of our rails, and as long as we keep that right, we can make a comparatively hard rail well adapted to wear.

In regard to the amount produced by the two methods in the same time, the hammer compares very favourably with the rolls. A blooming-mill turns out about 55 tons of blooms a day from ingots. We do as much as that daily under a 12-ton hammer, and have done much more than that for a considerable time, so that the relative capacity of the two is hardly decided as yet. In five to six minutes we can hammer down, chip, and cut in two, and carry away, a large ingot, reducing it to one-third its former size; and in thirty-five to forty minutes do the whole work of getting a heat of five ingots hammered complete into finished rail-blooms, requiring no subsequent hand-chipping. For three months this hammer did an average of about 70 tons of rail-blooms per day, turning them out sound and well chipped.

As a matter of interest, it may be well to refer to the fact, that at Neuberg, in Styria, they use a 19-ton hammer on steel, and according to published statements, produce under it in a week only 65 tons out of two furnaces in $11\frac{1}{2}$ turns. They hope, by using four furnaces, to get up to 130 tons a week. It shows well the spirit of American work to compare our product with this. We do now over three times as much as they hope to do, and do it under a hammer of under two-thirds the weight. The weight of ingots is about the same.

I have explained above my reasons for preferring hammered rails, all derived from experience capable of easy verification. In practice we have found, as far as we could compare hammered with rolled rails, that the former stand the treatment they have to suffer better than the rolled rails. From experience with rails of different making, rolled and hammered from ingots of the same size, I am enabled to say that the hammered ones have far less rejections on all accounts than the rolled ones, and that their strength against sudden jar is greater.

I believe, therefore, that the hammered rails are superior to the rolled in very important characteristics. I do not deny that rolling may be improved so as to equal a hammered rail. That is not impossible, nor improbable. It has not done it yet, in my opinion, but when it does, I shall be most happy to change my opinion.

In order to show the relative endurance of iron and steel rails I would like to mention a case that may be regarded as furnishing an American experience of steel rails, equalling that had on the English railroads, and especially on the London and North-Western. The Philadelphia, Wilmington, and Baltimore Railroad laid, in their yard in Philadelphia, steel rails on one side of the track, and iron rails on the other. The steel rails were hammered rails, and were, with the iron, laid in 1864. The steel rails wore out some 17 sets of the iron rails, and then the company stopped the experiment, laying steel on both sides.

On a curve of 525 ft. radius, steel rails have lasted intact since 1865, and are as perfect as when laid, where iron rails had before lasted only from three to six months.

None of the rails of the Pennsylvania Steel Company, nor of any other company in this country, have ever been worn out by traffic or shifting work, so that, after a five years' experience of American makes, I have reason to believe they will last at least a generation, under the hardest service.

SHIPBUILDING IN THE UNITED KINGDOM.

ACCORDING to the "Tables showing the progress of British merchant shipping," lately issued by the Board of Trade" (Parl. paper, No. 294), there were built in the United Kingdom, during the fifteen years ending December 31, 1872, in all, 5,133,716 tons of shipping, 4,832,014 tons being for home and the colonies, and the rest for foreign countries. The aggregate tonnages built during each year of the period is given in the appended table. It should be said that the returns for the years prior to 1871 denote the tonnage of the newly-built vessels "first registered" in those years; but the returns for 1871 and 1872 include the tonnage of all vessels "the building of which was completed" in the year, whether registered or not.

Total tonnage of vessels built in the United Kingdom in each year from 1858 *to* 1872.

Years.	For Home and the Colonies.	For Foreigners.	Total.	Remarks.
1858..	208,080	28,474	236,554	
1859..	185,970	26,774	212,744	
1860..	211,968	13,903	225,871	
1861..	200,839	7,487	208,326	
1862..	241,399	20,533	261,392	
1863..	364,724	17,320	382,044	
1864..	433,045	28,960	462,005	Including 6,497 tons built for war purposes for foreigners.
1865..	415,204	32,965	448,169	Including 3,700 tons
1866..	341,189	38,350	379,539	Do. do. Including 10,301 tons
1867..	269,080	36,899	305,979	Do. do. Including 4,994 tons
1868..	316,197	46,131	362,328	Do. do. Including 10,254 tons
1869..	354,287	33,805	388,092	Do. do. Including 2,354 tons
1870..	342,706	51,651	394,357	Do. do. Including 970 tons
1871..	354,355	36,703	391,058	Do. do. Including 80 tons
1872..	392,971	81,747	474,718	Do. do. Including 40 tons Do. do.

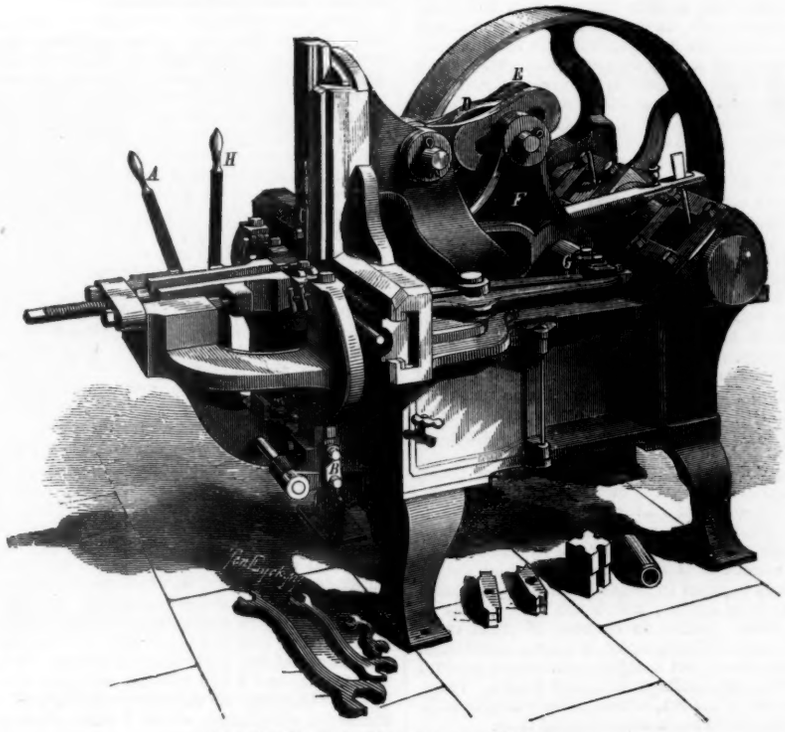
N.B.—Tonnage built for war purposes for foreigners not distinguished in the returns for the years previous to 1864.

ABBE'S PATENT BOLT-FORGING MACHINE.

IT has long been a conceded fact that, in forging bolts, the four or six sides of the head should be acted upon by the forging dies without moving the bolt blank from the position in which it is first held, and that the forging dies should be wider than the bolt head, so as to leave no fins on the corners of the head. The object of the inventor of the herewith illustrated machine has been to produce a tool which should combine these advantages with all the requirements of every class of bolt forging. Four dies are used, and the bolt is held firmly and securely in one position until finished, always, it is claimed, producing a bolt, under the head, just the size of the rod, with the sides of the head in parallel lines with the body. All classes of bolts and shapes of head desired are made, especially the fish joint or T-headed bolts, which, we are informed, cannot be made on machines where the bolt is turned to receive the action of the forging dies. The production of the apparatus varies, with the size of the bolt to be forged, from eight to sixteen perfect bolts per minute; and changing from one size of bolt to another, or from one shape of head to another, it is stated, requires hardly a moment's time, especially adapting the device to the use of railroad shops.

Among the points of advantage claimed are, first, simplicity; every bolt and joint being dispensed with except those which produce the result of working the four dies, while there are neither gears, cams, nor springs about the machine, thus saving to the user both the expense and the time occupied in making necessary repairs. The slides are all gibbed, so that any trifling wear can be readily taken up without removing the slides to put on a thin strip of iron. The sliding surfaces are always running in oil, as they are placed above the water and cinders. The machine is provided with a cupboard for its tools, a new feature in this class of devices.

The holding vice is operated by a handle, A, attached to the cross shaft. On each end of the latter are the arms, having links B, attached to work the sliding frame, which open the radial arms that carry the holding dies. These holders are backed up by a filling-in piece, adjusted forward by means of the screws. The



ABBE'S PATENT BOLT-FORGING MACHINE.

length of the bolt is gauged from one inch upward by adjusting the end screw. The driving wheel is in operation all the time: the machine only when it is forging the bolt. The long slide carries the bottom die on its lower end. The top slide die, C, works on the face of the long slide, which is actuated by two levers, D, E, having curved slots, the top die slide having one lever with reverse curve, all working on the same pin. The pin in the upset carrier, F, passes through the curved slots, and as it acts back and forth moves them in opposite directions. The side dies have their motion by means of links, G, attached to the upset carrier.

When the bolt blank is placed in the holders and clamped tightly by means of the handle, A, the handle, H, clutches in the driving wheel with the shaft, and the upset carrier advances by means of the connections to upset the iron, the forging dies being all open. As the upset carrier recedes to half stroke, the side dies compress the sides of the head; and at extreme end of stroke, the top and bottom dies act upon the other two sides of the head, and so continue to do until the bolt is finished, which is done in four revolutions of the driving wheel.

Two sizes of these machines are now being manufactured, one for both large and small bolts, and the other more particularly for the smaller sizes.—*Scientific American.*

INDIA-RUBBER SHOES FOR HORSES.

WE can describe this invention in no better or more concise terms than by stating that it is an india-rubber overshoe for horses. It is made and lined in precisely similar manner to the articles of apparel worn by the human race, and, in fact, presents no points of difference save in its shape and its manufacture from the best quality of india-rubber.

It is designed as a substitute for the iron shoe, and as a means of preventing the many maladies to which horses' feet are subject. The inventor informs us that horses suffering with cracked or contracted hoof, and similar painful hurts, are quickly cured by the substitution of the rubber covering for the unyielding metal shoe. The elasticity of the former allows the hoof to remain in its natural shape while protected from abrasion against pavements by the heavy rubber sole beneath.

The device is easily removed from or put on the hoof, and hence, while standing in the stall or turned out to pasture, the horse may be left barefooted. In winter time the covering serves as a protection against illness due to the common practice of mingling salt with the ice and snow in city streets, while the

roughened surface of the rubber beneath serves to give the animal a foothold in slippery weather.

As compared with iron shoes, the cost of the rubber ones is about one-third more, and their weight is some 40 per cent. less. Sixteen sizes are manufactured, so that accurate fits may be obtained. With reference to wear, the inventor states that the durability, owing to the fine quality of rubber employed, is very great. The device has been successfully used for some time past, and, we understand, has received the endorsement of the New York Society for the Prevention of Cruelty to Animals.—*Scientific American.*

THE ORIGIN OF METALLIFEROUS DEPOSITS.

By T. Sterry Hunt, LL.D., F.R.S.[1]

THERE are about sixty bodies which chemists call elements; the simplest forms of matter which they have been able to extract from the rocky crust of our earth, its waters and its atmosphere. These substances are distributed in very unequal quantities, and in very different manners. As regards the frequency of these elements in nature, neglecting for the present those which constitute air and water, and confining ourselves to the solid matters of the earth's crust, there are a few which are exceedingly abundant, making up nine-tenths, if not ninety-five hundredths, of the rocks so far as known to us. The elements of which silica, alumina, lime, magnesia, potash, and soda are oxides, are very common, and occur almost everywhere. There are others which are much rarer, being found in comparatively small quantities. Many of these rarer elements are, however, of great importance in the economy of nature. Such are the common metals and other substances used in the arts, which occur in nature in quantities relatively very minute, but which have been collected by various agencies, and thus made available for the wants of man. It is chiefly of the well-known metals, iron, copper, silver, and gold, that I propose to speak to-night; but there are two other elements, not classed among the metals, which I shall notice, for the reason that their history is extremely important, and will, moreover, enable us to comprehend more clearly some points in that of the metals themselves. I speak of phosphorus and iodine.

You all know the essential part which the former of these, combined as phosphate of lime, plays in the animal economy, in the formation of bones; and how plants require for their proper growth and development a certain amount of phosphorus. Ordinary soils contain only a few thousandths of this element, yet there are agencies at work in nature which gather this diffused phosphorus together in beds of mineral phosphates and in veins of crystalline apatite, which are now sought to enrich impoverished soils. Iodine, an element of great value in medicine and in the art of photography, is widely distributed, but still rarer than phosphorus, yet it abounds in certain mineral waters, and is, moreover, accumulated in marine plants. These extract it from the waters of the sea, where iodine exists in such minute quantities as almost to elude our chemical tests.

There are probably no perfect separations in nature. We cannot, without great precautions, get any chemical element in a state of absolute purity, and we have reason to believe that even the rarest elements are everywhere diffused in infinitesimal quantities. The spectroscope, which we have lately learned to apply to the investigation alike of the chemistry of our own earth and that of other worlds once supposed to be beyond the chemist's ken, not only demonstrates the very wide diffusion of various chemical elements here on earth, but shows us that very many of them exist in the sun. If we accept, as most of us are inclined to do, the nebular hopothesis, and admit that our earth was once, like the sun of to-day, an intensely heated vaporous mass; that it is, in fact, a cooled and condensed portion of that once great nebula of which the sun is also a part, we might expect to find all the elements now discovered in the sun distributed throughout this consolidated globe. We may speculate about the condensation of some of these before others, and their consequent accumulation in the inner parts of the earth, but the fact that we have all the elements of the solar envelope (together with many more) in the exterior portions of our planet, shows that there was, at least, but a very partial concentration and separation of these elements during the period of cooling and condensation. The superficial crust of the earth, from which all the rocks and minerals which we know have been generated, must have contained, diffused through it, from the earliest time, all the elements which we now meet with in our study of the earth, whether still diffused, or accumulated, as we often find the rarer elements, in particular veins or beds.

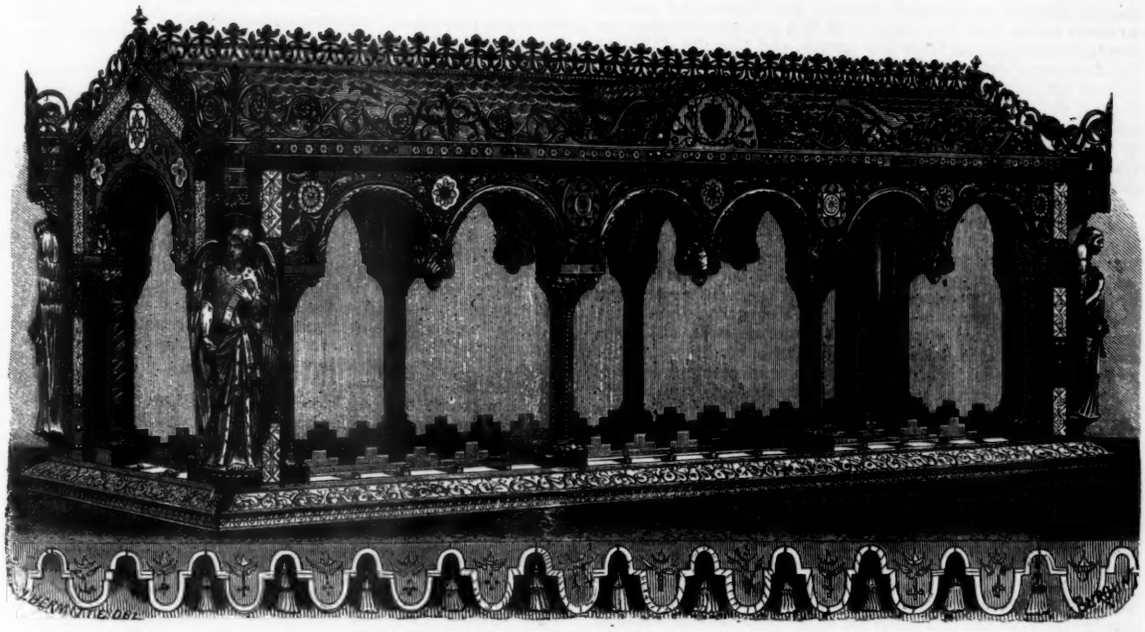
The question now before us is, how have these elements thus been brought together, and why is it that they are not all still widely and universally diffused? Why are the compounds of iron in beds by themselves, copper, silver, and gold gathered together in veins, and iodine concentrated in a few ores and certain mineral waters? That we may the better discern the direction in which we are to look for the solution of this problem, let us premise that all of these elements, in some of their combinations, are more or less soluble in water. There are, in fact, no such things in nature as absolutely insoluble bodies, but all, under certain conditions, are capable of being taken up by water, and again deposited from it. The alchemists sought in vain for a universal solvent, but we now know that water, aided in some cases by heat, pressure, and the presence of certain widely distributed substances, such as carbonic acid and alkaline carbonates and sulphides, will dissolve the most insoluble bodies; so that it may after all be looked upon as the long-sought-for alkahest or universal menstruum.

Let us now compare the waters of rivers, seas, and subterranean springs, thus impregnated with various chemical elements, with the blood which circulates through our own bodies. The analysis of the blood shows it to contain albuminoids which go to form muscle, fat for the adipose tissues, phosphate of lime for the bones, fluorides for the enamel of the teeth, sulphur, which enters largely into the composition of the hair and nails, soda, which accumulates in the bile, and potash, which abounds in the flesh-fluid. All of these are dissolved in the blood, and the great problem for the chemical physiologist is to determine how the living organism gathers them from this complex fluid, depositing them here and there, and giving to each part its proper material. This selection is generally ascribed to a certain vital force, peculiar to the living body. I shall not here discuss the vexed question of the nature of the force which determines the assimilation from the blood of these various matters for the needs of the animal organism, further than to say that modern investigations tend to show that it is only a subtler kind of chemistry, and that the study of the nature and relation of colloids and crystalloids, and of the phenomena of chemical diffusion, promises to subordinate all these obscure physiological processes to chemical and physical laws.

Let us now see how far the comparison which we have made between the earth and an animal organization will help us to understand the problem of the distribution of minerals in nature; how far water, the universal solvent, acting in accordance with known chemical and physical laws, will cause the separation of the mixed elements of the earth's crust, and their accumulation in veins and beds in the rocks. The subject is one of great importance to the geologist, who has to consider the genesis of the various rocks and ore-deposits, and the relations, which we are only beginning to understand, between certain metals and particular rocks, and between certain classes of ores and peculiar mineralogical and geological conditions. It is at the same time a vast one, and I can to-night only give you a few illustrations of the chemistry of the earth's crust, and of the laws of the terrestrial circulation, which I have compared to that of the blood distributing throughout the animal frame the elements necessary for its growth. The analogy is not altogether new, since a great French geologist, Elie de Beaumont, has already spoken of a terrestrial circulation in regard to certain elements in the earth's crust; though he has not, so far as I am aware, carried it out to the extent which I propose to-night in my attempt to explain some of the laws which have presided over the distribution of metals in the earth.

The chemist in his laboratory takes advantage of changes of temperature, and of the action of various solvents and precipitants, to separate, in the humid way, one element from another; but to these agencies, in the economy of nature, are added others which we have not yet succeeded in imitating, and which are exerted only in growing animals and plants. I repeat it, I do not wish to say that these latter processes are different in kind from those which we command in our laboratories, but rather that these organisms control a far finer and more delicate chemical and physical apparatus than we have yet invented. Plants have the power of selecting from the media in which they live the elements necessary for their support. The growing oak and the grass alike assimilate from the air and water the carbon, hydrogen, nitrogen, and oxygen which build up their tissues, and at the same time take from the soil a portion of phosphorus which, though minute, is in both cases essential to the vegetable growth. The acorn of the oak and grass alike become the food of animals, and the gathered phosphates pass into their bones, which are

[1] Transactions of the American Institute of Mining Engineers.



GEMS OF INDUSTRIAL ART.—Reliquary, by M. Trioullier and Sons.

nearly pure phosphate of lime. In like manner the phosphates from organic waste and decay find their way to the sea, and through the agency of marine vegetation become at last the bony skeletons of fishes. These are, in turn, the prey of carnivorous birds, whose exuviæ form on tropical islands beds of phosphatic guano. A history not dissimilar will explain the origin of beds of coprolites and other deposits of mineral phosphates.

But again, these plants or these animals may perish in the sea and be buried in its ooze. The phosphates which they have gathered are not lost, but become fixed in an insoluble form in the clayey matter; and when, in the revolutions of ages, these sea-muds, hardened to rock, become dry land, and crumble again to soil, the phosphates are there found ready for the wants of vegetation.

Most of what I have said of phosphates applies equally to the salts of potash, which are not less necessary to the growing plant. From the operation of these laws it results that neither of these elements is found in large quantities in the ocean. This great receptacle of the drainage of the land contains still smaller quantities of iodine; in fact, the traces of this element present in sea-water can scarcely be detected by our most delicate tests. Yet marine plants have the power of separating this iodine, and accumulating it in their tissues, so that the ashes of these plants are not only rich in phosphates and in potash-salts, but contain so much iodine that our supplies of this precious element are almost wholly derived from this source, and that the gathering and burning of sea-weed for the extraction of iodine is in some regions an important industry. When this marine vegetation decays, the iodine which it contains, appears, like the potash and phosphates, to pass into combinations with metals, earths, or earthy phosphates, which retain it in an insoluble state, and in certain cases yield it to percolating saline solutions, which thus give rise to springs rich in iodine.

In all of these processes, the action of organic life is direct and assimilative, but there are others in which its agency, although indirect, is not less important. I can hardly conceive of an accumulation of iron, copper, lead, silver, or gold, in the production of which animal or vegetable life has not either directly or indirectly been necessary, and I shall begin to explain my meaning by the case of iron. This, you are aware, is one of the most widely diffused elements in nature: all soils, all plants contain it; and it is a necessary element in our blood. Clays and loams contain, however, at best, two or three hundredths of the metal, but so mixed with other matters that we could never make it available for the wants of this iron age of ours. How does it happen that we also find it gathered together in great beds of ore, which furnish an abundant supply of the metal? The chemist knows that the iron, as diffused in the rocks, exists chiefly in combination with oxygen, with which it forms two principal compounds; the first, or protoxide, which is really soluble in water impregnated with carbonic acid or other feeble acids, and the second, or peroxide, which is insoluble in the same liquids. I do not here speak of the magnetic oxide, which may be looked upon as a compound of the other two, neutral and indifferent to the most natural chemical agencies. The combinations of the first oxide are either colourless or bluish or greenish in tint, while the peroxide is reddish-brown, and is the substance known as iron-rust. Ordinary brick-clays are bluish in colour, and contain combined iron in the state of protoxide, but when burned in a kiln they become reddish, because this oxide absorbs from the air a further proportion of oxygen, and is converted into peroxide. But there are clays which are white when burned, and are much prized for this reason. Many of these were once ferruginous clays, which have lost their iron by a process everywhere going on around us. If we dig a ditch in a moist soil which is covered with turf or with decaying vegetation, we may observe that the stagnant water which collects at the bottom soon becomes coated with a shining, iridescent scum, which looks somewhat like oil, but is really a compound of peroxide of iron. The water as it oozes from the soil is colourless, but has an inky taste from dissolved protoxide of iron. When exposed to the air, however, this absorbs oxygen, and peroxide is formed, which is no longer soluble, but separates as a film on the surface of the water, and finally sinks to the bottom as a reddish ochre, or, under somewhat different conditions, becomes aggregated as a massive iron ore. A process identical in kind with this has been at work at the earth's surface ever since there were decaying organic matters, dissolving the iron from the porous rocks, clays, and sands, and gathering it together in beds of iron ore or iron ochre. It is not necessary that these rocks and soils should contain the iron in the state of protoxide, since these organic products (which are themselves dissolved in the water) are able to remove a portion of the oxygen from the insoluble peroxide, and convert it into the soluble protoxide of iron, being themselves in part oxidized and converted into carbonic acid in the process.

We find in rock formations of very different ages beds of sediment which have been deprived of iron by organic agencies, and near them will generally be found the accumulated iron. Go into any coal region, and you will see evidences that this process was at work when the coal-beds were forming. The soil in which the coal-plants grew has been deprived of its iron, and when burned turns white, as do most of the slaty beds from the coal-rocks. It is this ancient soil which constitutes the so-called fire-clays, prized for making fire-bricks, which, from the absence of both iron and alkalies, are very infusible. Interstratified with these, we often find, in the form of ironstone, the separated metal; and thus from the same series of rocks may be obtained the fuel, the ore, and the fire-clay.

From what I have said it will be understood that great deposits of iron ore generally occur in the shape of beds; although waters holding the compounds of iron in solution have, in some cases, deposited them in fissures or openings in the rocks, thus forming true veins of ore, of which we shall speak further on. I wish now to insist upon the property which dying or dead organic matters possess of reducing to protoxide, and rendering soluble, the insoluble peroxide of iron diffused through the rocks; and reciprocally the power which this peroxide has of oxidizing and consuming these same organic matters, which are thereby finally converted into carbonic acid and water. This last action, let me say in passing, is illustrated by the destructive action of rusting iron fastenings on moist wood, and the effect of iron-stains in impairing the strength of linen fibre.

We see in the coal formation that the vegetable matter necessary for the production of the iron-ore beds was not wanting; but the question has been asked me, where are the evidences of the organic material which was required to produce the vast beds of iron ore found in the ancient crystalline rocks? I answer, that the organic matter was, in most cases, entirely consumed in producing these great results; and that it was the large proportion of iron diffused in the soils and waters of those early times, which not only rendered possible the accumulation of such great beds of ore, but oxidized and destroyed the organic matters which in later ages appear in coals, lignites, pyroschists, and bitumens. Some of the carbon of these early times is, however, still preserved in the form of graphite, and it would be possible to calculate how much carbonaceous material was consumed in the formation of the great iron-ore beds of the older rocks, and to determine of how much coal or lignite they are the equivalents.

In the course of ages, however, as a large proportion of the once diffused iron oxide has become segregated in the form of beds of ore, and thus removed from the terrestrial circulation, the conditions have grown more favourable for the preservation of the carbonaceous products of vegetable life. The crystalline, magnetic and specular oxides, which constitute a large proportion of the ores of this metal, are almost or altogether indifferent to the action of organic matter. When, however, these ores are reduced in our furnaces, and the resulting metal is exposed to the oxidizing action of a moist atmosphere, it is again converted into iron-rust, which is soluble in water holding organic matters, and may thus be made to enter once more into the terrestrial circulation.

There is another form in which iron is frequently concentrated in nature, that of sulphide, and most frequently as the bi-sulphide known as iron pyrites. This substance is found both in the oldest and the newest rocks, and, like the oxide of iron, is even to-day forming in certain waters, and in beds of mud and silt, where it sometimes takes a beautifully crystalline shape.

What are the conditions in which the sulphide of iron is formed and deposited, instead of the oxide or carbonate of iron? Its production depends, like these, on decaying organic matters. The sulphates of lime and magnesia, which abound in sea-water, and in many other natural waters, when exposed to the action of decaying plants or animals, out of contact of air, are, like peroxide of iron, deoxidized, and are thereby converted into soluble sulphides; from which, if carbonic acid be present, sulphuretted hydrogen gas is set free. Such soluble sulphides, or sulphuretted hydrogen, are the reagents constantly employed in our laboratories to convert the soluble compounds of many of the common metals—such as iron, zinc, lead, copper, and silver—into sulphides which are insoluble in water and in many acids, and are thus conveniently separated from a great many other bodies. Now, when in a water holding iron-oxide, sulphates are also present, the action of organic matter, deoxidizing the latter, furnishes the reagent necessary to convert the iron into a sulphide; which in some conditions, not well understood, contains two equivalents of sulphur for one of iron, and constitutes iron pyrites. I may here say that I have found that the unstable protosulphide which would naturally be first formed, may, under the influence of a persalt of iron, lose one-half of its combined iron; and that from this reaction a stable sulphide results.

This subject of the origin of iron pyrites is still under investigation.

The reducing action of organic matters upon soluble sulphates is well seen in the sulphuretted hydrogen which is evolved from the stagnant sea-water in the hold of a ship, and which coats silver exposed to it with a black film of sulphide of silver, and for the same reason discolours white lead paint. The presence of sulphur in the exhalations from some other decaying matters is well known, and in all these cases a soluble compound of iron will act as a disinfectant, partly by fixing the sulphur as an insoluble sulphide. Silver coins brought from the ancient wreck of a treasure-ship in the Spanish Main were found to be deeply incrusted with sulphide of silver, formed in the ocean's depths by the process just explained, which is one that must go on wherever organic matters and sea-water are present, and atmospheric oxygen excluded.

The chemical history of iron is peculiar; since it requires reducing matters to bring it into solution, and since it may be precipitated alike by oxidation, and by farther reduction, provided sulphates are present. The metals, copper, lead, and silver, on the contrary, form compounds more or less soluble in water, from which they are not precipitated by oxygen, but only by reducing agents, which may separate them in some cases in a metallic state, but more frequently as sulphides. The solubility of the salts and oxides of these metals in water is such that they are found in many mineral springs, in the waters that flow from certain mines, and in the ocean itself, the waters of which have been found to contain copper, silver, and lead. Why, then, do not these metals accumulate in the sea, as the salts of soda have done during long ages? The direct agency of organic life comes again into play, precisely as in the case of phosphorus, iodine, and potash. Marine plants, which absorb these from the sea-water, take up at the same time the metals just named, traces of all of which are found in the ashes of sea-weeds. Copper, moreover, is met with in notable quantities in the blood of many marine molluscous animals, to which it may be as necessary as iron is to our own bodies. Indeed, the blood of man, and of the higher animals, appears never to be without traces of copper as well as of iron.

In the open ocean the waters are constantly aerated, so that soluble sulphides are never formed, and the only way in which these dissolved metals can be removed and converted into sulphides is by fixing them in organisms, either vegetable or animal. These, by their decay in the mud of the bottom, or the lagoons of the shore, generate the sulphides which fix their contained metals in an insoluble form, and thus remove them from the terrestrial circulation.

It is not, however, in all cases necessary to invoke the direct action of organisms to separate from water the dissolved metals. It often happens that the waters containing these, instead of finding their way to the ocean, flow into lakes or inclosed basins, as in the case of the drainage-waters of an English copper-mine, which have impregnated the turf of a neighbouring bog to such an extent that its ashes have been found a profitable source of copper. Under certain conditions, not yet well understood, this metal is precipitated by organic matters in the metallic state, but if sulphates are present a sulphide is formed. Thus, in certain mesozoic schists in Bohemia, sulphide of copper is found incrusting the remains of fishes, and in the sandstones of New Jersey we find it penetrating the stems of ancient trees. I have in my possession a portion of a small trunk taken from the mud of a spring in Ontario, in which the yet undecayed wood of the centre is seen to be incrusted by hard metallic iron pyrites. In like manner the old trees of the New Jersey sandstone became incrusted with copper sulphide which, as decay went on, in great part replaced the woody tissue. Similar deposits of copper and of iron often took place in basins where the organic matter was present, in such a condition or of such a quantity as to be entirely decomposed, and to leave no trace of its form, unlike the examples just mentioned. In this way have been formed pfahl-bands, and beds of pyrites and other ores.

The fact that such deposits are associated with silver and with gold leads to the conclusion that these metals have obeyed the same laws as iron and copper. It is known that both persalts of iron and soluble sulphides have the power of rendering gold soluble, and its subsequent deposition in the metallic state is then easily understood.

I have endeavoured by a few illustrations to show you by what processes some of the more common metals are dissolved and again separated from their solution in insoluble forms. It now remains to say somewhat of the geological relations of ore deposits, which are naturally divided into two clauses; the first including those which occur in beds, and have been formed contemporaneously with the inclosing earthy sediments. Such are the beds of iron ores which often hold imbedded shells and other organic remains, and the copper-bearing strata already mentioned, in which the metal must have been deposited during the decay of the animal or plant which it incrusts or replaces. But there are other ore deposits evidently of more recent formation than the rocky strata which enclose them, which have resulted from a process of filtration, filling up fissures with the ore, or diffusing it irregularly through the rock. It is not always easy to distinguish between the two classes of deposits. Thus a fissure may in some cases be formed and filled between two sundered beds, from which may result a vein that may be mistaken for an interposed stratum. Again, a bed may be so porous that infiltrating waters may diffuse through it a metallic ore, or a metal, in such a manner as to leave it doubtful whether the process was contemporaneous with the disposition of the bed, or posterior to it. But I wish to speak of deposits which are evidently posterior, and occupy fissures in previously formed strata, constituting true veins. Whether produced by the great movements of the earth's crust, or by the local contraction of the rocks (and both of these causes have in different cases been in operation), such fissures sometimes extend to great lengths and depths; their arrangement and dimensions depending very much on the texture of the rocks which have been subjected to fracture. When a bone in our bodies is broken, nature goes to work to repair the fractured part, and gradually brings to it bony matter, which fills up the little interval, and at length makes the severed part one again. So when there are fractures in the earth's crust, the circulating waters deposit in the openings mineral matters, which unite the broken portions, and thus make whole again the shattered rocks. Vein-stones are thus formed, and are the work of nature's conservative surgery.

Water, as we have seen, is a universal solvent, and the matters which it may bring and deposit in the fissures of the earth are very various. There is scarcely a spar or an ore to be met with in the stratified rocks that is not also found in some of these vein-stones, which are often very heterogeneous in composition. In certain veins we find the elements of lime-stone or of granite, and these often include the gems, such as amethyst, topaz, garnet, hyacinth, emerald, and sapphire; while others abound in native metals or in metallic oxides or sulphides. The nature of the materials thus deposited depends very much on conditions of temperature and of pressure, which affect the solvent power of the liquid, and still more upon the nature of the adjacent rocks and of the waters permeating them. The chemistry of mineral veins is very complicated. Many of these fissures penetrate to a depth of thousands of feet of the earth's crust, and along the channels thus opened the ascending heated subterranean waters may receive in their course various contributions from the overlying strata. From these additions, and from the diminished solubility resulting from a decrease of pressure, deposits of different minerals are formed upon the walls, and the slow changes in composition are often represented by successive layers of unlike substances. The power of these waters to dissolve and bring from the lower strata their contained metals and spars is probably due in great part to the alkaline carbonates and sulphides which these waters often hold in solution; but the chemical history of their deposit in the ores of iron, lead, copper, silver, tin, and gold, which are found in these veins, demands a lengthened study, and would furnish not less beautiful examples of nature's chemistry than those I have already laid before you.

The process of filling veins has been going on from the earliest ages; we know of some which were formed before the Cambrian rocks were deposited, while others are still forming, as the observations of Phillips have shown us in Nevada, where hot springs rise to the surface and deposit silica, with metallic ores, which incrust the walls of the fissures. These thermal waters show that the agencies which in past times gave rise to the rich mineral deposits of our Western regions, are still at work there.

Let us now consider the beneficent results of the process of vein making. The precious metals, such as silver, are so sparsely distributed, that even the beds rich in the products of decaying sea-weed, which we have supposed to be deposited from the ocean, would contain too little silver to be profitably extracted. But in the course of ages these sediments, deeply buried, are lixiviated by permeating solutions, which dissolves the silver diffused through a vast mass of rock, and subsequently deposit it in some fissure, it may be in strata far above, as a rich silver ore. This is nature's process of concentration.

We learn from the history which we have just sketched the important conclusion, that amid all the changes of the face of the globe the economy of nature has remained the same. We are apt, in explaining the appearance of the earth's crust, to refer the formation of ore-beds and veins to some distant and remote period, when conditions very unlike the present prevailed, when great convulsions took place, and mysterious forces were at work. Yet the same chemical and physical laws are now, as then, in operation; in one part dissolving the iron from the

sediments and forming ore-beds, in another separating the rarer metals from the ocean's waters; while in still other regions the consolidated and buried sediments are permeated by heated waters, to which they give up their metallic matters, to be subsequently deposited in veins. These forces are always in operation, rearranging the chaotic admixture of elements which results from the constant change and decay around us. The laws which the first great cause imposed upon this material universe on the first day are still irresistibly at work fashioning its present order. One great design and purpose is seen to bind in necessary harmony the operations of the mineral with those of the vegetable and animal worlds, and to make all of these contribute to that terrestrial circulation which maintains the life of our mother earth.

While the phenomena of the material world have been looked upon as chemical and physical, it has been customary to speak of those of the organic world as vital. The tendency of modern investigation is, however, to regard the processes of animal and vegetable growth as themselves purely chemical and physical. That this is to a great extent true must be admitted, though I am not prepared to concede that we have in chemical and physical processes the whole secret of organic life. Still we are, in many respects, approximating the phenomena of the organic world to those of the mineral kingdom; and we at the same time learn that these so far interact and depend upon each other that we begin to see a certain truth underlying the notion of those old philosophers who extended to the mineral world the notion of a vital force; which led them to speak of the earth as a great living organism, and to look upon the various changes in its air, its waters, and its rocky depths, as processes belonging to the life of our planet.

Since this lecture was delivered, I have seen the results of the researches of Sonstadt on the iodine in sea-water, which appear in the "Chemical News" for April 26, May 17, and May 24, 1871. According to him this element exists in sea-water, under ordinary conditions, as iodate of calcium, to the amount of about one part of the iodate in 250,000 parts of the water. This compound, by decaying organic matter (and by most other reducing agents) is changed to iodide, from which, apparently, by the action of carbonic acid, iodine is set free, and may be separated by agitating the water with bisulphide of carbon. The iodine thus liberated from sea-water by the action of dead organic matters, however, slowly decomposes water in presence of carbonate of calcium, and is reconverted into iodate, the oxygen of the air probably intervening to complete the oxidation, since, according to Sonstadt, iodides are readily converted into iodates under these conditions. He finds that the insolubility of the iodides of silver and of copper is so great that by the use of salts of these metals iodine may be separated from sea-water without concentration, provided the iodate of calcium has first been reduced to iodide. By this property of iodine and its compounds to oxidize and be oxidized in turn, Sonstadt supposes them to perform the important function of consuming the products of organic decay, and so maintaining the salubrity of the ocean's waters. Their action would thus be very similar to that of the oxides of iron, as explained in the present lecture.

Still more recently the same chemist has announced that the sea-water of the British coasts contains in solution besides silver an appreciable quantity of gold, estimated by him at about one grain to a ton of water. This is separated by the addition of chloride of barium, apparently as an aurate of baryta adhering to the precipitated sulphate, which yields by assay an alloy of about six parts of gold to four of copper. Other methods have been devised by him for separating these metals from their solution in sea-water. The agent which keeps the gold of the sea in a soluble and oxidized condition is, according to Sonstadt, the iodine liberated by the action already described.

The views maintained by Lieber, Wurtz, Genth, and Selwyn, as to the solution and redeposition of gold in modern alluvial deposits seem to be well grounded, and we are led to the conclusion that the circulation of this metal in nature is as easily effected as that of iron or of copper. The transfer of certain other elements, such as titanium, chrome, and tin, or at least their accumulation in concentrated forms, appears, on the contrary, to require conditions which are no longer operative at the surface of the earth.

It should here be noticed that Prof. Henry Wurtz, of New York, in a paper read before the American Association for the Advancement of Science, in 1868, expressed the opinion that the ocean waters contained gold, and urged experiments for its detection. According to his calculations the total amount of gold hitherto extracted from the earth, and estimated at two thousand million dollars, would give only one dollar for two hundred and eighty millions of tons of sea-water, while from the experiments of Sonstadt, it would appear that the same quantity of gold is actually contained in twenty-five tons of water.

Chemistry applied to the Arts, Metallurgy, Chemical Manufactures, and Allied Subjects.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF CHEMICAL SOCIETIES, &c.

§ 1. *Acids, Alkalies, and Salts.*

Purification of Sulphuric Acid.—F. Bode states that, at Freiburg, the following method is employed for the preparation of sulphuric acid free from arsenic:—Sulphuretted hydrogen is generated by the action of waste acid, washings, &c., on plumbiferous sulphides of iron obtained in the Harz during the smelting of lead ore, by fluxing with metallic iron; these sulphides contain much silver, which accumulates in the masses insoluble in the acid used. The sulphides, broken into masses the size of a fist, are placed in stout leaden vessels, arranged on the principle of the ordinary laboratory arrangement, where the pressure of gas, generated in the vessel containing the sulphide, expels the acid into a second vessel connected with the first by a tube, when a current of gas is not required, and when consequently the exit of gas from the generator is prevented. The vessels used are of 2 to 3 cubic metres capacity; those in which the lumps of sulphide are placed are coated internally with a cement capable of resisting the action of acid, and fluted in channels. To prevent the deposition of solid sulphate of iron, a steam heat may be applied to the bottom of the generator.

The sulphuretted hydrogen thus produced is made to act on chamber acid at 50° B. The apparatus used for this purpose is a leaden quadrangular tower, 1·133 metre by 1·7 metre along the sides, and 5 metres high. This is filled internally with leaden tiles, or small roof-shaped plates, so arranged that the eaves of one roof are just over the ridges of the next higher roof. Ten parallel roofs of this kind are placed in each horizontal tier. The acid trickles over these leaden roofs, and thus exposes a large surface to the action of the sulphuretted hydrogen, which is let in at the bottom of the tower. The sulphide of arsenic thus formed is deposited in settling tanks, and the acid is finally filtered. *Bulletin Soc. Chim. Paris, xxii.* 322, *from Dingler's Polytech. Journal, ccxiii.* 25.

Loss of Nitre in Vitriol Making.—W. Hasenbach finds that the nitrous compound present in chamber acid is always peroxide of nitrogen, and not nitrous acid. Sulphurous acid completely denitrates such acid, but the reduction of nitrogen oxides takes place so vigorously that not only is nitric oxide formed, but even nitrous oxide. The average amount of nitrogen found by the author in chamber acid is about 0·11 gramme per litre, which represents nearly 17 grammes of nitrate of soda per cubic foot; or per 60,000 quintals of acid at 60°, 38 quintals of nitrate of soda. This represents about 6 per cent. of the total nitre employed in making the acid. *Bulletin Soc. Chim. Paris, xxii.* 327, *from Berichte der Deut. Chem. Ges. vii.* 678.

Improved Pyrites Roaster.—C. Meyerhoff patents an improved oven for the roasting of pyrites, and the extraction and precipitation therefrom the fumes of arsenical and other poisonous vapours. This new oven is constructed with two furnaces, the flues of which pass round a central shaft, the flues communicating with the shaft by means of grate openings. The pyrites to be burnt are placed in the shaft, and are removable by an opening at the bottom, closed at pleasure by a sliding door of boiler plate. Under the opening of the shaft, a small cone is built up. When the door is withdrawn the burnt pyrites are spread out by falling down the sides of the cone into the exhaust pit, where they are allowed to cool. The top of the shaft communicates with an iron pipe or flue, dipping at its further end under the surface of water in a closed vessel, a pipe from which leads to the chimney. The fumes rising from the furnace are made to pass onwards by means of a fan. Previously to the burning, the pyrites are prepared by mixing with them one-third their weight of pipeclay, or common sludge, the mixture being "masted" with a solution of common salt in water, after which the mass is moulded into lumps.

Preparation of Acetic Acid.—B. Hirsch states that acetic acid is best obtained by the use of the following mixture;

if strong sulphuric acid only be employed, a larger amount is requisite :—

Acetate of soda	10 parts.
Sulphuric acid diluted with twice its weight of water	2 „

Chem. Centralblatt, 1874, 166.

Carbolic Acid.—LOWE and GILL patent the following process for the separation of carbolic acid from the cresylic and other liquid tar acids. This is effected by (1) submitting the partially or wholly hydrated mixtures of tar acids for a sufficiently prolonged time to a temperature varying between 15° F. and 56° F. ; (2) separating the carbolic acid crystals thus formed from the mother liquors containing the liquid tar acids, and a residue of carbolic acid dissolved in them ; (3) effecting complete purification of the carbolic acid crystals thus obtained by recrystallisation, either by partial fusion or solution in water with subsequent refrigeration ; (4) preparing carbolic acid of high degrees of purity by dehydrating the carbolic acid crystals above mentioned.

Iodine.—REYNOSO patents the following processes for the extraction of iodine from iodates, mother liquors from "caliche" working or from Chili saltpetre, &c. :—

A. The mixture containing *iodate* is acidulated with nitric or sulphuric acid, added in quantity proportionate to the richness ; an electric current is then passed, whereby scales of iodine are deposited, but little being left in solution ; this small quantity may be extracted by agitating the liquors separated from the precipitated iodine with benzole, sulphide of carbon, or other suitable solvent ; the iodine solution thus obtained is distilled, or agitated with potash or soda ; by evaporation and calcination a pure iodide is thus produced. Instead of employing an electric current, metallic zinc may be used to precipitate the iodine ; or sulphurous acid gas in large excess may be blown through the liquid, and copper sulphate added ; iodide of copper is thus thrown down, and this can be decomposed by a current of air in presence of oxide of iron or manganese.

B. If the iodine be present as *iodide*, it may be acidulated, and a galvanic current sent through ; or sulphate of copper may be added, and the whole agitated with a solvent for iodine, &c.

Liquors containing iodate may be partially reduced by means of sulphurous acid or bisulphite of soda, and then mixed with another portion of the original liquor and acidulated ; the iodide and iodate thus decompose one another, iodine being precipitated. Conversely, liquor containing iodide may be oxidized to iodate by means of bleaching powder or chlorine, and then treated with zinc and sulphuric acid or by an electric current.

Iodine may also be separated from liquors containing iodides by adding chlorate of potash or soda and a mineral acid ; according to the quantity of chlorate added, either the contained iodine compounds are converted into iodic acid, which is then precipitated by ferrous, stannous, or other reducing salts ; or into free iodine, which precipitates. The iodine may also be thrown down in combination with copper by the addition of sulphate, nitrate, chloride of copper or other copper salt ; the precipitate is then digested with plates of copper, whereby cuprous iodide is formed ; this is then decomposed by nitric acid ; iodine is thus set free, and nitrate of copper generated, ready for use over again. *Bull. Soc. Chim. Paris, xxii.* 331.

Iodine in Chili, Saltpetre, &c.—A. GUYARD states that iodine exists in nitre, in the form of iodate of potassium, and not in that of iodide of sodium or of iodate of sodium ; periodate of sodium is sometimes present. When the iodine is present as iodate, it is always contained as potassium salt, whilst if present as periodate, it uniformly occurs as sodium salt. *Chem. News, xxx.* 196, *from Bull. Soc. Chim. Paris, xxii. No.* 2.

Manufacture of Soda by the Ammonia Process.—C. LIST states that the transformation of common salt into bicarbonate is effected by means of three distinct vessels : in the first a strong brine is prepared ; this is saturated with ammonia in the second ; whilst the impregnation of the ammoniacal liquor with carbonic acid is effected in the third.

The first is simply a chambered reservoir, into which water is led ; this, passing over the salt in the different compartments, finally issues as brine at 25° B. ; this strong brine is slightly reduced to 23° or 24° by addition of a little water, and filtered into the second vessel consisting of a cylindrical tin-plate or leaden reservoir covered with wood, and provided with a false bottom perforated with holes, so as to divide into bubbles the stream of ammonia gas led in from below ; when saturated, the volume is largely increased, and the density lowered to 13° to 16° B. ; by means of an overflow-pipe suitably adjusted, the liquor runs off as it attains the density 16° B. ; as considerable heat is generated during the saturation process, the liquor is cooled in a refrigerator, and thence run into the *absorber :* this is a cylinder 11 to 16 metres high, containing perforated shelves, over and through which the ammoniacal brine runs from a tank at top, whilst carbonic acid gas is forced in at bottom by a pump at a pressure of 1¼ to 2 atmospheres ; in expanding this gas takes up just about as much heat as is liberated by the combination of the carbonic acid with the ammonia. The tank containing the liquor is closed in, and is placed at an elevation of about 3 metres above the top of the cylinder, so that the pressure exerted by the gases in the cylinder is the same in the cylinder itself and in the tank ; several absorbers are fed from the same tank. Every half hour the carbonated liquor is partially let off and filtered ; bicarbonate of soda in suspension is thus separated, whilst the mother liquor contains little but chloride of ammonium ; the deposition of *solid* bicarbonate in the absorber is apt to block up the holes in the shelves ; when this occurs, the absorber must be emptied and washed with water and steam, and then started again with fresh liquor.

The solid bicarbonate thus obtained is vacuum-drained in the filters, and washed with a little water ; it may then be dried by a current of warm air, or may be heated by means of superheated steam or lime-kiln gases, so as to produce the ordinary carbonate : for this purpose, it is convenient to use a vertical cylinder, in the interior of which is arranged a series of circular plates having alternately an opening in the centre, and cavities at the periphery ; these plates may be hollow, so as to be heated by steam, or a current of hot air may be led through the cylinder. In the axis of the cylinder is an axle carrying arms so disposed as to rake the bicarbonate gradually from one shelf to another through the perforations in the plates ; the bicarbonate is introduced by a jigging box at the top ; this should be always full, so as to prevent loss of the evolved carbonic acid gas by leakage here. A side pipe proceeding from the top of the cylinder carries the carbonic acid to the absorbers, where it is used over again.

To regain the ammonia, the liquors containing chloride of ammonium are treated either with lime or magnesia ; in the latter case the magnesium chloride formed is calcined, so as to regenerate magnesia, which is used over again ; hydrochloric acid is thereby produced as a bye-product of the process. *Bull. Soc. Chim. Paris, xxii.* 320; *from Dingler's Polytech. Journal, ccxii.* 507.

Alkali Manufacture.—J. S. MACDOUGALL patents an improved form of furnace : the fireplace is arranged in a chamber situate at one end of the brickwork containing the furnace, the length of the fireplace being crosswise to the breadth of the furnace. Extending longitudinally from the upper side portion of the fireplace chamber and backwards therefrom immediately underneath the furnace is a flue inclining upwards to the end of the furnace, and divided transversely into a number of smaller upright flues by division walls which are built the full length of the furnace bed. The crown of the fireplace chamber is formed of a strong double-ringed brick arch, over which is laid a tile of 3 in. thick, forming a portion of the furnace bed. This arch spans from the outside walls of the fireplace chamber to the top ends of the division walls, connecting which to a distance of about 4 ft. back from the fireplace chamber is a series of small one-brick arches. Over these arches are laid tiles 3 in. thick, forming another portion of the furnace bed, the remaining portion of the latter being formed by placing along its entire length a double layer of 3 in. tiles covering the upright spaces or flues between the division walls. At the back end of and resting transversely on, the furnace bed is a bridge wall, to prevent the contents of the furnace falling into the flues and fire underneath.

HARGREAVES and ROBINSON modify Leblanc's process by adding to the mixture of soda sulphate and coal some metallic oxide, and afterwards heating the mixture in a closed vessel to a heat sufficient to form a porous mass on cooling, but not sufficient to fuse the mixture. The metallic oxides are those of iron, zinc, lead, calcium, or any metal whose oxide is capable of decomposing sulphide of sodium. Six parts of soda sulphate, two of coal, and five of iron peroxide proves an advantageous mixture.

After heating, the mass is allowed to cool before being exposed to the atmosphere, and the alkali separated by lixiviation. The metallic sulphide left after the latter operation may be used in the manufacture of Glauber salt, whilst the oxide obtained by burning the metallic sulphide can again be employed as admixture to the soda sulphate and coal.

Recovery of Soda from Spent Leys.—DUFAY patents the following process. The leys are causticized with lime whilst still hot ; siliceous, resinous, and other organic matters are thus removed as insoluble lime compounds ; the clarified liquor is

carbonated by a current of carbonic acid, and used over again for esparto, straw, jute, &c. Evaporation to dryness and calcination of the residue are thus rendered unnecessary. *Bulletin Soc. Chim. Paris, xxii.* 335.

Lithia in the Soil, &c.—P. TRUCHOT states that the soils of Limagne contain very considerable amounts of lithium, varying from 0·031 to 0·132 grammes of carbonate per 100 grammes of soil, from 0·5 to 0·6 grammes of potash being also present. All plants grown in such soils contain lithium, readily detected by means of the spectroscope.

All mineral waters in Auvergne contain lithium in quantities varying from 0·008 to 0·035 grammes of chloride per litre; thus :—

	Lithium chloride per litre.	
Water from Mont Doré . . .	8	milligrammes
„ Royat (Cæsar's Spring) .	9	„
„ Clermont {Saline spring .	14	„
„ Clermont {Artesian well .	20	„
„ La Bourboule . .	18	„
„ Saint Nectaire . .	22	„
„ Chatel-Guyon . .	28	„
„ Saint Alyre . . .	31	„
„ Les Roches . . .	33	„
„ Châteauneuf . . .	35	„
„ Royat (another spring) .	35	„

Comptes Rendus, lxxviii. 1022.

Cinchona Barks from Outacamund.—E. DE VRIJ gives the following analyses of various kinds of barks of cinchona trees cultivated at Outacamund; the increased amount of quinine in the renewed bark of cinchona succirubra is noteworthy, and will prove excessively valuable should further experience confirm the fact as being general.

	Total alkaloids.	Pure quinine.
Cinchona succirubra :—		
Original bark, 8 years old . .	10·86	0·79
Renewed „ 2 „ . .	10·40	4·65
Ditto „ 2 „ (another specimen)	9·15	2·75
Renewed bark, 2 years old (another specimen)	10·67	1·41
Renewed bark, 2 years old (another specimen)	8·70	1·38
Renewed bark, 2 years old (another specimen)	8·18	1·18
Renewed bark, 2 years old (another specimen)	10·37	2·02
Cinchona panudiana :—		
Original bark	2·51	0·03
Ditto „	2·02	0·60
Renewed bark, 2 years old . .	4·80	0·78
Cinchona officinalis :—		
Renewed bark, 2 years old . .	10·86	2·80
„ „ . .	6·94	1·27
„ „ . .	6·73	1·68
„ „ . .	4·29	0·82
„ „ . .	3·72	2·60

Pharm. Journ. Trans. [3] *iv.* 869.

§ 2. *Metallurgy.*

Mechanical Puddling Process of Pernot.—J. PETRIE states that the Danks furnace is open to the objection that so large a ball is necessarily obtained that special shinglers and laminators must be used as well as reheating furnaces, so that the plant ordinarily employed is useless for this process. Pernot's process consists in the adaptation to the ordinary puddling furnace of a rotating bed, the axis of rotation being inclined so that the sole is sometimes under the molten iron and sometimes exposed to the oxidizing atmosphere of the furnace; the ordinary shinglers, &c. are used with this arrangement, the bloom weighing 300 to 500 kilogs., although 800 to 1000 kilogs. can readily be worked in this way. The iron thus produced is said to be superior to that made in the ordinary furnaces, and double the yield is obtained for a given amount of labour, whilst less fuel is required; the saving is said to be as much as 21 to 22 francs per ton.

500 kilogs. of pig iron heated to redness in a reheating furnace are melted in 35 minutes; about 3 turns per minute are then given; in 10 minutes thickening commences, when the temperature is raised; the reaction lasts about 30 minutes, after which the metal is worked for 25 minutes and then formed into balls for 30 minutes. About 2½ hours are required for a perfect charge.—*Bull. Soc. Chim. Paris, xxii.* 326, *from Revue Uuiverselle des Mines, xxxv.* 199.

New Puddling Furnaces.—RILEY and HENLEY have devised a new form of furnace, made in the shape of a circular revolving pan with slanting sides. The pan is caused to revolve by any suitable means; the most preferable method being to mount the revolving pan on a vertical shaft which is set revolving by bevel gear; the shaft is supported by a footstep and a collar or neck bearing arranged in a cross-shaped bracket, which also at its four legs or arms stays the bottom of the two opposite outer furnace plates, back and front together. The driving gear for this revolving pan has two or more motions worked by frictional clutches, and may also, if desired, be worked by a separate engine, the speed of which is under the direct control of the puddler. The top of the pan is formed with a flange all round, either cast on, or made separately of cast or wrought iron and fastened on. This flange or hanging lip dips into a circular trough kept constantly supplied with water, thus forming a water lute and keeping the air from entering into the pan at any part of the circumference, the outside of the pan at the same time being exposed to a full current of air, especially while the pan is revolving.

To prevent the rushing in of air into the pan from between the trough and the surrounding brickwork, a flange with a hanging lip is fastened to the brickwork all round the trough, the hanging lip also dipping into this trough and forming a lute joint there. To bring about a better diffusion of heat, the trough may be made to revolve.

The upper edge of the pan may be cast hollow to form a water compartment all round, and this compartment is connected to a central tube with an internal tube, with swivel tube joints at the bottom of the vertical shaft, and so arranged as to cause a continual circulation of water.

The other portions of this new puddling furnace are built up and stayed by bolts and plates like the ordinary puddling furnaces, only that the plates at the back and front of the revolving bottom are cut short below so as to admit the air freely there. An ordinary puddling furnace can thus be easily converted according to this invention.

The tools used in connection with this furnace are somewhat different from the ordinary appliances. During the first stage of the process a tool is employed which resembles the customary rabble, but having a hook which is caused to rest against the inside of the rabble hole in order to obtain a hold against the revolving mass of iron in the pan; the iron is thus agitated rapidly while on the boil. During the "boiling" of the iron a blast may be used, consisting of a thin broad flat current of air, diffused across the surface of the iron in a slanting direction towards the neck of the furnace, and from the side opposite to the rabble hole. When the iron begins to "form," the speed is reduced as required, and the puddler then makes use of another tool, which the inventors call the plough, because it approaches in its shape the form of a ploughshare, and causes a complete turning over, breaking up, and clearing of the iron. When thus sufficiently worked, the iron is balled in the usual manner, and that either from one or both sides and in balls of any required size.

Improved Smelting Furnace.—R. JUKES has constructed a reverberatory furnace, consisting of a jacketed cupola; water is admitted into the jacket so as to keep the masonry cool by its circulation.

Use of the Spectroscope in Puddling.—A. MACMARTIN states that the spectrum at first appears without lines; but as soon as the spark period begins to give place to its successor, and the clear flame to extend out of the mouth of the converter, the bright orange-yellow sodium line quickly makes its appearance, and remains clearly visible till the blast is turned off. After the sodium line appear the red lines, which represent calcium and lithium; and then a beautiful series of perfectly graded green lines in the green, and pale blue lines in the blue section of the spectrum, manifest themselves, one after another, each in its series, until, at the climax of the operation, when the greatest heat is attained, the spectrum rivals that of chloride of copper in beauty and brilliancy. A very experienced eye can also sometimes see a beautiful violet line in the violet section at this point.

The characteristic lines of the Bessemer spectrum are the beautiful band-like graduated series in the blue, and especially in the green, section. In the inverse order to that in which they arose to their climax, these lines gradually diminish in brilliancy, and at last vanish. But some of the green lines still remain, after the blue series has entirely vanished; and at this point nothing must be allowed to distract the conductor of the opera-

tion from closely watching the spectrum; for the only index (though a perfect one) of the exact end of the operation, is the degree of brilliancy of certain green lines, which remain when the charge has arrived at the point of desired decarburisation. For different mixtures of pig-iron a slight difference in the appearance of the indicating green lines is noticeable at this point; and to secure with the same mixture a desired slight difference in the grade of steel produced in two different blows, proper allowance must be made, on one or the other side, of a certain degree of brilliancy of the green lines. *Paper read before the American Institute of Mining Engineers.*

Terre-Noire Phosphorized Steel.—EUVERTE states that the object of adding spiegeleisen to the completely decarburized and partially oxidized iron obtained in the Bessemer process is to destroy the oxide of iron formed, which presents a great impediment to the malleability of the metal; the addition of carbon in the spiegeleisen communicates hardness and steely characters, but renders the metal unfit for rolling into plates and for other purposes where strength together with softeness is requisite. At Terre-Noire a higher manganiferous spiegeleisen, containing 40 to 42 per cent. of manganese, is prepared by a slight modification of Henderson's process for the preparation of *ferro-manganese* (containing 25 to 30 per cent. of manganese); this can be sold at 2·0 to 2·50 francs per kilog., and the low price permits of valuable metal being made at a moderate cost; thus extra soft plates are prepared for the navy of France, having a resistance of 45 to 50 kilogs. per square millimetre, and far superior to any even of the best-known soft irons.

By the aid of this manganese alloy it is practicable to obtain a good steel from phosphorized iron, the condition being that the more phosphorus there is present in the steel, the less carbon must be there: a steel containing 0·30 per cent. of phosphorus and 0·15 per cent. of carbon, is malleable and gives rails of very good quality; hence phosphorized ores may be readily converted into good cast steel. *Bulletin Soc. Chim. Paris, xxii.* 324; *from Revue Universelle des Mines, xxiv.* 1873, 519.

Cementation Steel.—BOUSSINGAULT gives the following analysis of the iron used for cementation and of the resulting steel, from which it appears that nearly one half of the contained sulphur is eliminated by this process; probably the diminution in iron is due to the formation of chloride from the action of alkaline chlorides in the cement powder.

	Before Cementation.	After.	Difference.
Weight used . .	4949·45	4994·20	+44·45
Iron	4905·00	4914·30	— 0·70
Carbon	5·84	49·69	+43·85
Silicon	5·20	5·34	+ 0·14
Sulphur	0·59	0·30	— 0·29
Phosphorus . .	4·95	6·24	+ 1·29
Manganese . . .	10·99	10·99	none.
Other elements .	16·98	17·33	+ 0·35

Iron, No. xciii. 522.

[Probably the loss of sulphur is also due, to some extent, to the action of the chlorides.—ED.]

Etching of Iron and Steel.—F. KICK recommends to etch iron and steel with the following mixture:—

Hydrochloric acid	½-litre.
Water	½-litre.
Concentrated solution of antimonious chloride	1 drop.

The last ingredient is added to prevent rusting of the etched parts. Soft and fine grained metal is more equally acted on than other sorts. *Dingler's Polytech. Journal, ccxii.* 40.

Galvanized Iron.—The use of iron coated with zinc (improperly known as galvanized iron) has enormously increased since 1837, when the first English patent was taken out by H. W. Crawford, who applied it chiefly to sheets of corrugated iron, or sheet iron bent into alternate semi-circular elevations and depressions; this soon became extensively employed for roofing purposes, especially for railway sheds, which were then beginning to be in great request.

The enormous demand that soon sprang up for galvanized iron, especially in sheets, attracted considerable attention in America, and led to improvements in machinery for its preparation, and simultaneously it was adopted as a desirable substitute for wood and stone wherever it could be employed. By various improvements on Crawford's patent, the effectual coating of sheets, or other articles of iron, was found to render it by far the most economical means for covering buildings, as it requires no paint and withstands the action of the atmosphere for a very considerable length of time.

There are, besides, other qualities possessed by this material, which render it far preferable to wood or stone for many purposes to which the former is applied, among which its lightness and elasticity, its fireproof qualities and its great durability may be mentioned. For cornices, in America, it has almost entirely superseded both wood and stone, the immense weight of stone necessary to give the required projection being one of the principal objections to its use, while the danger to wood from fire, besides its great cost, precludes its employment as a cheap, durable, and substantial material. Besides the absorption of moisture, to which American freestone is liable, causes it to scale after damp and frosty weather, while in case of fire it is liable to split and fly to pieces. Its cost, moreover, is about four times as much as that of galvanized iron, while the latter will look better and wear out any quality of stone that may be employed. *Iron, No. xcv.* 586.

Hardening Saws and Springs.—Saws and springs are generally hardened by being immersed in various compositions of oil, suet, wax, and the like materials. The usual way of proceeding is to heat the saws in long furnaces and then to immerse them horizontally and edgewise in a long trough containing the composition; two troughs are commonly used alternately. Part of the composition is wiped off with a piece of leather, when the articles are removed from the trough; they are then heated one by one over a clear coke fire until the grease inflames; this is called "blazing off."

A greatly recommended composition consists of two pounds of suet and a quarter of a pound of beeswax to every gallon of whale oil; these are boiled together, and will serve for thin articles and most kinds of steel. The addition of black resin, to the extent of about one pound to the gallon, makes it serve for thicker pieces, and for those it refused to harden before; but the resin should be added with judgment, or the articles will become too hard and brittle. The composition is useless when it has been constantly employed for about a month; the period depends, however, on the extent to which it is used, and the trough should be thoroughly cleansed out before the new mixture is placed in it. The following recipe is recommended:—

Twenty gallons of spermaceti oil; twenty pounds of melted and strained beef suet, one gallon of neatsfoot oil; one pound of pitch; three pounds of black resin.

These last two articles must be previously melted together, and then added to the other ingredients; the whole must then be heated in a proper iron vessel, with a close cover fitted to it, until the moisture is entirely evaporated and the composition will take fire on a flaming body being presented to its surface; the flame must be instantly extinguished again by putting on the cover of the vessel.

When the saws are wanted to be rather hard, but little of the grease is burned off; when milder a large portion; and for a spring temper, the whole is allowed to burn away.

When the work is thick, or irregularly thick and thin, as in some springs, a second and third dose is burned off, to ensure equality of temper at all points alike.

Gun-lock springs are sometimes literally fried in oil for a considerable time over a fire in an iron tray; the thick parts are then sure to be sufficiently reduced, and the thin parts do not become the more softened from the continuance of the blazing heat.

Springs and saws appear to lose their elasticity after hardening and tempering from the reduction and friction they undergo in grinding and polishing. Toward the conclusion of the manufacture, the elasticity of the saw is restored principally by hammering, and partly by heating over a clear coke fire, to a straw colour; the tint is removed by very diluted muriatic acid; after which the saws are well washed in plain water and dried.

Protection of Cast-Iron Pipes.—ENGELHARDT states that the water from mines frequently contains enough acid to attack cast-iron pipes, destroying them in a short time. Oil colours and varnishes offer but a limited resistance; and the process of enamelling employed in Upper Silesia, although permanent and effective, is expensive. Cement is cheaper, and is not acted upon by these waters, and the only question to be settled was whether it would adhere to the smooth iron with sufficient firmness.

Two similar pieces of rolled iron were taken, and one of them painted over five times with a very thin cement, so that the coating was four or five millimetres thick. Both pieces were suspended near together in that part of the shaft where the water had attacked the signal cable most violently, and were left there four months. On taking them out, the unprotected iron was found to be reduced to one-third its original thickness; the other,

in which a hole had been bored to suspend it, had suffered the same corrosion at the exposed portion; the cement covering was dark brown, but perfectly hard and unattacked by the acid. The cement was broken off, and the surface of the iron exhibited the dark blue colour and lustre that it had on leaving the rolls.

As this coating adhered so well to the smooth rolled iron, to which it cannot cling as tightly as to the rougher surface of cast iron, the experiment was continued on a larger scale. A 63-centimetre discharge pipe in the Oeyhausen shaft was protected on the inside with cement. The coating remained unchanged for two years, while the pump was in constant operation. At the beginning of last winter the pump was stopped, and the pipe being no longer under water, the cement was so much injured by the frost, that it scaled off. Several other experiments were made with similar results.

The pipes should be new, or, if old, well cleaned from rust, before applying the cement, which is mixed as thin as is possible without injury to its tenacity. The pipe is moistened before the cement is applied, a thin coating of cement is put on and allowed to dry; when hard, it is moistened, and a second coating applied, and so on four or five times. The operation cannot be conducted so well in very hot weather, as the cement dries too quickly; nor must the pipes be exposed to frost during the operation, or afterwards. This unfortunate sensitiveness to cold may perhaps yet be overcome by intervening some semi-elastic material between the iron and cement. *Iron, No.* 88, *p.* 361.

Electro-deposition of Iron.—VOLGER states that KLEIN has succeeded in perfecting this process, so as to render it completely industrial. By means of an ammoniacal solution of sulphate of iron (sulphate of iron and sal-ammoniac solution) and a Meidinger battery, with an iron positive pole, plates of iron can be deposited of all qualities and sizes; various articles can be thus produced, notably plates for engraving, uniting the softness of copper for engraving with the steel-like hardness of the plate for printing. In all cases, the first iron precipitate is brittle, being in fact an alloy of iron and hydrogen; but on annealing the hydrogen is expelled and the iron increases in density from 7·675 to 7·811, and becomes perfectly malleable, flexible and elastic, and possesses all the properties of the best hammered iron.

Steel reproductions of engraved plates were exhibited, and also a block made up of strips of the deposited iron welded together, forged, filed and polished, and a shield reproducing perfectly an elaborate *repoussé* composition of the "Battle of the Amazons," with a plateau weighing 15 lbs. The most valuable application of electro-iron is its employment in stereotype works, and especially in the case of printing in colours for bank notes, cheques, stamps, &c., as iron is not affected by mercurial pigments, which ruin copper, and type and other metals. *Paper read before the Frankfort Society of Physical Sciences.*

Extraction and Refining of Copper.—A. GALLICO patents the following process:—The ore is ground and watered with salt water, then roasted, afterwards watered again with salt water, then exposed in basins, in which the material is lixiviated with salt water and sulphuric acid. The material, being reduced to the consistency of a thick liquid, is passed through a succession of basins, filtered, and eventually compressed and dried.

Welding Copper.—REHBENS, ROBERTS and BROCCHUS patent the following process, in which there seems to be but little novelty:—The two pieces of copper to be united having previously been shaped so that the surfaces form a lap or other suitable joint, prepared borax (biborate of soda) is applied on and between the surfaces of the joint, which are heated and hammered. The borax is prepared by being heated until all the water of crystallization has evaporated, when the residuum is pulverized for use. After being hammered while hot, the joint is farther heated to a white heat, and sprinkled over with a chloride, such as magnesic, sodic (common salt), or other equivalent compound, suitable for the exclusion of the oxygen, and then finally welded; or during the welding operation a stream of chlorine gas may be directed upon the heated copper joint.

New Process for Copper Engraving.—BOUQUET DE LA GRYE proposes to cover the copper-plate with a thin, strongly adherent coating of silver; the silvered plate is then varnished with a coloured resist, and the engraving traced with a dry point; the etching is then bitten in by perchloride of iron. In this way the aquafortis process is ameliorated, since the adherence of the silver renders the graving as clean as the tracing itself; this would be a defect for portraits, but is essential for cards. *Bulletin Soc. Chim. Paris, xxii.* 330, *from Comptes Rendus, xxviii.* 1535.

Phosphor-bronze.—RUNZEL states that, when phosphor-bronze is combined with a certain fixed proportion of lead, the phosphorized triple alloy, when cast into a bar or bearing, segregates into two distinct alloys, one of which is hard and tough phosphor-bronze, containing but little lead, and the other a much softer alloy, consisting chiefly of lead, with a small proportion of tin and traces of copper. The latter alloy is almost white, and, when the casting is fractured, it will be found nearly equally diffused through it; the phosphor-bronze alloy forming, as it were, a species of metallic sponge, all of whose cavities are occupied by the soft metal alloy segregated from it. This phenomenon of the segregation into two or more alloys of combinations of copper with tin and zinc has long been known, and from the fact that such separation is generally massive, and not equable throughout the mass, it has been a source of great annoyance to the founder. The author has succeeded in causing the segregation to take place in uniform distribution throughout the casting, and has taken advantage of the properties of the product which he obtains in this manner, to construct therefrom bearings of railway and other machinery.

In heavy bearings, such as those for marine engines, the valuable properties of Babbit metal, and similar anti-friction alloys, are well recognized; but, these being generally soft, are open to the grave objection that where they are subjected to considerable pressure, or even moderate pressure accompanied by continued vibration, they become distorted in form, and then fail to sustain the journals in their proper places. The device is therefore resorted to by the machinist, of casting a hollow cage of hard metal, of proper form for the intended bearing, the cavities of which he then fills up by casting into them the soft metal alloy, which thus forms the actual rubbing surface of the bearing. The hard metal cage thus supports the soft metal within, and prevents its distortion or escape, save by surface abrasion. Runzel claims to effect the same result by the peculiar constitution of his new phosphorized alloy for bearings. This forms its own supporting cage for the soft bearing metal, which, as alluded to at the outset, separates from it in the process of cooling. He claims that these bearings combine the very small friction and non-abrasion of the journals due to soft metal, with the firm resistance to pressure and stability of form of bearings of hard metals. *Iron, No. xciii.* 522.

Utilization of Tin-plate.—J. STUART patents the following process for separating the tin from the iron in tin-plate cuttings and scraps, and in obtaining these metals separate; also for the manufacture of sulphate of ammonia, chloride of ammonium, sulphate of iron, and sulphate of zinc. The invention consists in subjecting tin-plate cuttings and scraps to the action of dilute sulphuric acid and atmospheric air, or to the action of dilute sulphuric acid and nitric acid, or dilute sulphuric acid and nitrous acid, or hydrochloric acid and any of the above combinations or compounds of oxygen and nitrogen, whereby the tin is separated from the iron and remains in solution, from which it is precipitated in the form of metal by placing in the liquor plates of zinc. The sulphates and chloride above mentioned are obtained in the process as by-products.

Tin-lined Lead Piping.—J. J. HARROP patents the following process for manufacturing tin-lined lead piping and for coating electric cables with lead. For tin-lined lead piping the ingot is cast in the press; a crosshead connected with the ramhead carries the core bar, so that it moves with the same velocity as the die. With a rising container, the pipe is formed issuing downwards through a sliding tube, the fresh compound ingot is cast on the top of the portion of the previous ingot left at the bottom of the container. In the case of lead-coating a telegraph cable, the cable passes upwards through the sliding tube down which the lead pipe or covering is forced. The inner rams are supplied with water by means of pipes sliding in glands on the supply pipes; the container is heated by a mixture of air and gas; and the winding drums are driven by power, which may be by differential motion, a traversing guide regulating the coiling of the finished pipe.

Assaying Quicksilver Ores.—H. G. HANKS states that the following rough method of examining quicksilver ores is extensively used in California, where there is a great demand for mercury, and where cinnabar has been recently found in large quantities. The ore is washed just as in gold washing. If the rock contains cinnabar an intensely red powder, fringing the residue, will be obtained for a "prospect;" if mercury in a metallic state, minute globules will be the result. After a few trials the prospector can decide at a glance whether his ore contains mercury, and approximately the quantity. The best vessel for this assay is the "batea," or conical wooden bowl.

The batea originated in Brazil, where it is in common use in the diamond and gold mines. It is a turned circular dish, of dark-coloured hard wood, of about 1 ft. in diameter, but sometimes

more. The centre of the disc is depressed, the radii forming an angle of about 160°. The manner of using the batea may be described as follows :—

A great quantity of water is required contained in a tank or large tub, or at a convenient place near the bank of a stream or lake. The pulverized ore—several pounds at a time—is placed in the batea, which is gradually sunk in the water. Several times it is broken down with the fingers, while the batea floats on the water. When the ore is thoroughly wet and formed into mud, the batea is taken by the rim with both hands and again sunk in the water. A circular motion is then imparted to it (soon learned by practice). The lighter particles will continuously flow over the edges and sink, while the heavier ones collect at the centre. When only a small portion remains, the batea may be lifted, and the water held in the depression caused to sweep round the centre, while one edge is slightly depressed. This motion will gradually remove the heavier particles toward the depressed part. If there is any gold, platinum, galena, cinnabar or other unusually heavy substance, its gravity will resist the power of the water, while the comparatively light particles move slowly forward. The form of the vessel is such that the heaviest matter forms a point, and can be closely observed. If there is a particle of cinnabar present, it will be found at the point of the prospect, clearly distinct from all other substances.

As the foregoing method of assaying for mercury never gives results absolutely correct, the assayer must often practice the wet assay in cases where great accuracy is required. To conduct this assay, all the appliances of an analytical laboratory, and considerable skill in manipulating, are requisite. The usual reduction agent is proto-chloride of tin. The mercury compound, if solid, must be digested with strong hydrochloric acid and carefully decanted. This process must be repeated until all the mercury is in solution. If the solution of proto-chloride of tin is not clear, it must be made so by adding a drop or two of hydrochloric acid. The clear solution must then be added to the mercury solution in slight excess; the whole is then boiled, but only for a moment, to prevent loss by volatilization. On cooling, the mercury is found in the form of a black precipitate. The supernatant liquid must then be removed with a syphon and the precipitate boiled with dilute hydrochloric acid, which causes the mercury to form globules. It is then well washed, first with very dilute hydrochloric acid and finally with distilled water. It is then dried, first with bibulous paper and then under a bell glass, over sulphuric acid. After which it is weighed. *Iron, No. xciii.* 524.

Extraction of Silver and Gold by Aaron's Amalgamation process.—AARON states that ores cannot be ground too fine; but there is considerable difference in ores as to the amount of loss experienced from deficiency in this respect; thus some ores will readily yield 90 per cent. of the silver present and 80 per cent. of the gold present without fine crushing, whilst others must be passed through a 60-mesh screen to give first-rate results.

The essential "chemical" is cuprous chloride. Cupric chloride acts equally well on the ore; but it also acts injuriously on mercury. Moreover, it is inevitably reduced to cuprous chloride in the course of working. When the ore contains no copper oxide or carbonate, or not sufficient, it is best to prepare cuprous chloride by boiling, by means of a jet of steam in a wooden vat containing scrap copper, a solution of copper sulphate, and sodium chloride (salt), till the colour of the solution is no longer green, but brown; and a little of it cooled in a test tube deposits a copious white precipitate. Or, a solution of copper sulphate and salt may be boiled with just enough iron borings to precipitate one half of the copper in the solution. When the precipitated copper is redissolved, cuprous chloride is formed. The solution must contain an excess of salt above the quantity requisite to convert the copper sulphate to chloride; and, if not used immediately, should be kept excluded from the air, to prevent its conversion into insoluble oxychloride. A little of the latter may, however, be beneficial in some cases. It will answer, though not so well, to put the copper sulphate and salt directly into the amalgamating barrel with the pulp; either leaving the copper balls, which are always used in the barrel, to do the work of forming the cuprous chloride, or adding the proper quantity of iron borings. It must be observed that when iron borings are used for this purpose, double as much copper sulphate is required as when copper is used. A sodic chloride of copper may be made in the dry way; but this does not seem to be convenient.

With ores containing copper in the form of oxide or carbonate, a solution of sulphurous acid in water, with the addition of salt, produces cuprous chloride at very little cost. The next best way is to add to the pulp in the barrel a quantity of iron protosulphate (copperas) and salt, producing cupric chloride, which, reacting on copper carbonate in the ore, forms a mixture of the two chlorides of copper.

Acids may be used with this class of ores in conjunction with salt, but as they are disagreeable to handle, and produce only cupric chloride, they are not preferable, unless when the ore contains cuprous oxide, in which case sulphuric acid may be used with advantage. Salt, in excess of the quantity decomposed by the chemicals, is always necessary. The copper and iron sulphates require rather more than half their weight of salt to convert them into chlorides, and at least 50 lb. more should be used to a ton of ore. From 5 lb. to 50 lb. of copper sulphate, or its equivalent of the other substances, will generally be found sufficient. In whatever way the cuprous chloride is finally obtained, there must be enough of it dissolved in the hot pulp to show a distinct coat of copper on a clean piece of iron. With the class of ores just mentioned, containing copper, it is usual to put in, together with the chemicals, a quantity of iron borings. It acts by precipitating rapidly an equivalent of cement copper, at the same time producing iron chloride, which dissolves an equal quantity of copper from the ore. The precipitated copper acts in two ways. First by reducing to cuprous chloride any cupric chloride which may be present; second, by reducing to a metallic state the silver salt formed by the action of copper chlorides on the ore. This silver salt, if not a simple chloride, is so far similar as to be reducible by copper; for which reason, as the quantity of iron cannot be accurately adjusted, and moreover, an excess of copper is necessary in practice, a quantity of metallic copper, usually in the form of balls, or small bars, is used in the amalgamating barrel. The quantity of iron borings which may be used with advantage may be as much as 50 lb. per ton of ore, varying with the quality of the ore and the kind and quantity of the chemicals. Its effect is to hasten the operation, to protect the mercury which may unavoidably remain in the barrel when discharged, and to economise the consumption of the copper balls. Its use must be regulated by the quality of amalgam obtained, as too much causes the production of coppery bullion.

Mercury should not be put in till several hours after charging, except when the cuprous chloride is made beforehand, or when, with coppery ores, the solution of sulphurous acid is used; in these cases there is no danger of its being granulated.

Authorities differ as to the manner in which copper chlorides act upon silver ore. Some even doubt if silver chloride is formed, but it seems singular that they all speak of silver sulphide only. The author's experiments show: 1st, that silver sulphide (natural) is reduced to metallic silver by copper oxychloride; 2nd, that silver sulphide (artificial) is converted to chloride by the two copper chlorides; 3rd, that quartzite digested with either of the chlorides of copper, or with copper oxychloride and salt, produces a silver compound almost wholly soluble in hyposulphite of soda; calomel also reduces silver ores.

GRUTZNER states that calomel is reduced to metallic mercury by cuprous sulphide, but the author has been unable to verify this, obtaining only cuprous chloride and no metallic mercury, but apparently mercury sulphide.

Barrels appear to be the most convenient for the amalgamating process; the common Freiburg barrel, with a hole bored in each journal, one to admit steam, the other as an outlet to prevent danger of bursting, will answer well. It should be lined with wooden blocks, placed so that the grain of the wood is vertical to the axis of the barrel. To make the blocks, a 3-inch plank is cut into pieces 2 inches long. The blocks thus made are then bevelled with the jack-plane to suit the circle of the barrel. There is no need of great nicety in this work, and they should be put in as loosely as they can be made to stay, to allow for swelling. A manhole in the head of the barrel is necessary to allow the entrance of the workmen, and when the lining is worn through it is removed and renewed. The lining may be dispensed with if the copper, in the form of long bars, is fixed lengthwise in the barrel at the distance of about half an inch from the staves. This arrangement answers very well, and saves room and weight, as well as avoiding the wear of copper, which, in working poor ores, is apt to reduce the fineness of the bullion, thus entailing a double loss; but it necessitates the use of enough mercury to wash the amalgam from the copper bars, on which it is inclined to stick, or the barrel must be cooled occasionally so that a man can enter, and the accumulated amalgam beaten off the bars; or again, so little quicksilver must be used as only to moisten, so to speak, the reduced silver, in which case it will not adhere to the copper. Working in this way quicksilver must be used in the settler to gather the floating amalgam. When loose copper is used, small flat bars, or pieces about 3 inches long cut from a round bar, are preferable to balls, as they cause a more even wear of the lining. A lining of two inches thick will last, with a little repairing, several months. The best arrangement of the barrels is that seen in all works treating of the Freiburg process, where a V trough extends

lengthwise under one or a dozen barrels conducting the discharged pulp, &c. to the separator. The main portion of quicksilver and amalgam must be arrested in the trough or sluice, by a riffle or recess, and not allowed to go into the separator, unless two separators are used one after the other.

The separator preferred by the author consists of a wooden tub 6 ft. in diameter and 4 ft. deep, in the bottom of which is an iron annular disc, raised 1½ in. from the bottom of the tub by a smaller disc of wood under it, which leaves the iron disc projecting about 2 inches. The muller is made of scantling, and the arms are short, not reaching to within 6 inches of the side of the tub.

The mortises are arranged with keys, so that the muller can be clamped tightly to the square wooden shaft, the lower end of which runs on a low wooden cone having a core of mountain mahogany, and rising from the bottom of the tub up through the iron disc to a height of several inches. The upper end of the wooden shaft is connected with a short iron shaft, working in boxes attached to the framing, and carrying the pulley or gearing. The wooden shaft should be arranged to slide upon the iron portion, so that the muller may drop as it wears away, or may be raised with a lever in case of accident. The shorter the arms are the higher speed is used; and it should be such that the sand and particles of quicksilver are kept in continual suspension, till the latter, gathering together in a mass, settles into the annular space around the iron disc, where it remains undisturbed, while the sand remaining in suspension is drawn off with the water by successive plug-holes in the sides of the tub. Any pieces of rock or copper, &c., which may accidentally find their way into the machine, lodge under the projecting edge of the iron disc.

The amount of quicksilver lost is in the usual process enormous, being from 1 to 4 lbs. per lb. of silver extracted (Phillips). The author lost as much as 9 lbs. per ton of ore when using a wooden separator; but finally traced the cause of most of this loss to the formation of a red or purple powder which would not develop globules of mercury either by rubbing or by treatment with acids or alkalies; when treated with cuprous chloride and iron, however, this red substance yielded metallic mercury; hence the author treats the pulp formed in the barrel in the following way before allowing it to pass into the separator; the warm pulp as discharged from the barrel, and already containing excess of cuprous chloride, is worked for an hour or two in an iron-bottomed separator scoured by a wooden muller; the red powder is thus reduced and a copper amalgam formed, whereby the loss of mercury is very greatly diminished.

The low amalgam obtained from the separator contains a good deal of silver, chiefly due to a portion of fine amalgam which unavoidably passes with the pulp from the barrel. It may be used in the barrel in place of a portion of iron borings, or retorted, and either sold as low bullion, or melted into balls for the barrel.

In retorting this kind of amalgam there occurs, to a certain extent, a separation of copper from silver, which is more complete as the retorting is urged more speedily; so that the spongy mass of metal may be separated into three classes: one nearly fine silver, one nearly pure copper, and a medium. This process is not, like roasting, a panacea for all the ills that silver ores are heir to. Its suitability for any particular ore is best determined by digesting a weighed portion of the pulverized sample, dosed with chemicals in accordance to the explanations already given, in a glass or porcelain dish, with a piece of copper and some quicksilver, till it no longer gives a precipitate of silver on a piece of clean copper. The resulting silver, referred to the quantity of ore worked, and compared with the assay value of the ore, will give the percentage extracted. In testing the pulp with iron, to ascertain if the proper quantity of chemicals has been used, it will sometimes give a black coat instead of the copper colour. In this case it will often be found that by letting the barrel run a couple of hours, the proper appearance will be got, but if not, more chemicals are needed.

The bullion obtained will, with good management, be from 900 to 990 fine, no matter what the ore may contain. The quicksilver is always clean and bright, and the loss need not exceed 2 lb. per ton of ore. The expense of chemicals is light—in most cases far less than that of roasting, while the percentage of silver extracted is not surpassed, if equalled, by any other process; being, in Benton, from 80 to 97 per cent. of the assay value. *Iron, Nos.* 93 *and* 94, *pp.* 519 *and* 557.

Argentiferous Lead Mines.—Extensive silver-bearing lead deposits have been recently discovered in Montgomery county, Arkansas, forty miles west of Hot Springs. The vein is enclosed in a matrix of quartz, of all degrees of richness, from 10 up to 60 per cent. of galena, or from 7 up to 45 per cent. of metallic lead, with no contaminating metals but silver and arsenic. It is classed as 40 to 50 ounces silver ore. The wall rock is hornblende slate; the ledge 7 feet in width at a depth of 15 feet. *Iron, No.* 87, *p.* 333.

Extraction of Gold and Silver from Copper Ores.—F. ZWICKL proposes a process consisting of a combination of operations, namely, smelting of the ores in a reverberatory furnace to a mat, with admixture of sulphate of soda, for the purpose of disintegration; oxidation of the disintegrated mat in a furnace similar to that of a common roasting furnace, suitably adapted to prevent the heat from rising above the desired degree; repetition of this oxidation after the first is finished, and the product of it has been soaked with water; dissolving the sulphate of copper formed during the said oxidation in a tank with water, and after removal of the solution, dissolving the copper still left in the residue with a solution of sulphate of iron, this latter process being repeated as long as any copper is left in the residue; the copper in solution is then precipitated with iron. The residue, containing peroxide of iron and all the gold and silver, being much reduced in bulk, can be treated by any known method for the extraction of the gold and silver, or used as a flux for smelting the ores, and so accumulating the bullion as far as desired.

Sodium Wire.—A. W. HOFMANN prepares sodium in the form of wire by means of a brass cylinder furnished with a piston moved by a screw, and provided at the other end with a delivery plate pierced by a hole of suitable diameter; the cylinder is arranged vertically, the lower end dipping into a vessel containing petroleum to prevent oxidation of the metal wire; on turning the screw, the soft metal is "squirted" out as wire. *Berichte der Deut. Chem. Ges. vii.* 530.

§ 3. *Dyeing, Calico-Printing, Bleaching, Tanning, Pigments, and allied subjects.*

Croissant and Bretonnière's New Colours.—All colours can be produced except reds, blues, and greens, and good results are obtained when they are mixed with wood colours or logwood. To produce 1 cwt. of artificial dyestuff of the same tint as logwood costs about 30*s.*, whilst the same amount of logwood extract costs £7 10*s.* By treating chestnut, fustic, or logwood extracts themselves by Croissant and Bretonnière's process, but little extra cost is incurred (5 centimes per kilog. for chestnut, 20 for fustic, and 68 for logwood), whilst the tinctorial power is increased three or four fold.

These colours are not affected by light, acids, oxalate of potash, or hot soda lye, and they render other colours (*e.g.* aniline colours) more permanent than they otherwise would be. They are applied in a very simple fashion, being only dissolved in hot water to the proper strength. The goods are soaked for thirty to forty-five minutes, and fixed by bichromate of potash, after which they are washed with dilute acid, and finally with weak soda lye and pure water. Silk, wool, linen, and cotton are all dyed equally well, wherefore mixed goods can be dyed without appearing checkered. The following receipts are given, the numbers referring to the distinguishing marks of the various dyes, and the quantities being adapted to 20 kilogs. of linen, or 13 of cotton; the water used must be free from lime:—

Greys.—No. 1. 268, 670, or 1,200 grammes to 90 litres of water.

Yellowish Shades.—No. 7. 400 or 1,200 grammes to 90 litres of water.

Other Modes.—No. 1. 670 grammes to 90 litres of water.
No. 11. 667, 400, 600, or 800 grammes to 90 litres of water.
No. 13. 2, 3, or 4 litres to 90 litres of water.

Browns and Blacks.—No. 15 or No. 18. 400 or 1,200 grammes to 90 litres of water.
No. 1. 100 or 400 grammes to 90 litres of water.
No. 11. 1,000 grammes to 90 litres of water.
No. 13. 1½ litres to 90 litres of water.

Chrome bath for the above—

Water	80 litres.
Bichromate of potash	105 grammes.

Soda bath—

Soda	1 kilog.
Water	80 litres.

Chemical News, xxx. 180.

Anthracene Dyes.—G. AUERBACH and T. GESSERT patent the following process for manufacturing alizarine and isopurpurine out of anthracene. The anthracene is heated with concentrated sulphuric acid to a high temperature, and the pro-

duct is neutralized by an alkaline carbonate or with caustic alkali. The mixture then contains the neutral sulphates of the alkaline bases employed and acid sulphates thereof. The neutral sulphates are removed by filtration or crystallization, and the acid sulphates are neutralized by a farther addition of carbonate of soda or potash. The product neutralized as described is then heated along with caustic soda or potash as long as a bluish or red colour is produced. From this product a precipitate of alizarine and isopurpurine is obtained on the addition of an acid.

Chromic Acid as a Dye.—E. JACQUEMIN finds that chromic acid can combine with silk and wool, giving a yellow compound that resists washing and soaping. The wool is first passed through a bath of carbonate of soda at 60° C., containing about one-fifth as much carbonate as there is used of wool; it is then washed and introduced into the following bath (per kilog. of wool):—

Bichromate	60 grammes.
Sulphuric acid at 66° B.	60 „
Water	40-50 litres.

For light straw yellow, the wool is kept in for a few minutes at 30° C.; for darker shades, twenty minutes at a temperature not above 60° is required. Wool thus prepared takes up aniline and other colours with more or less modification of the shades, according to circumstances. *Comptes Rendus, No.* 8, 1874.

Gris d'Argent on Cottons.—Dissolve the dyestuff in boiling water, and slightly sour with sulphuric acid; dye cold at first, slowly raising to boiling; when finished rinse well. 10 to 15 grammes will dye a kilog. of cotton. *Reimann's Färberzeitung, No.* 36, 1874.

Lilac for Cottons.—SAUVAGE gives the following receipt:—Fifty kilogs. of goods are passed through an indigo bath, washed, treated with a weak tannin bath, and finally passed through a bath containing 1·5 kilogs. of bichromate. After washing, the goods are allowed to remain in a bath made from 7·5 kilogs. of sandalwood and 3·5 kilogs. of logwood for an hour in the cold, after which the bath is heated to boiling for an hour. They are then taken out, whilst 4 kilogs. of alum and 4 litres of hydrochloric acid are added to the liquor, after which they are again immersed. Finally, they are washed and wrung, and passed through a bath of logwood and alum; after twelve hours they are washed and treated with oil. In one week the operation is completed, instead of requiring six weeks; a less expensive fabric also can be used. *Chem. Soc. Journal, xii.* 1027, *from Dingler's Polytech. Journal, ccxi.* 403.

Cotton Blue without Mordant.—Bleached cotton should be used, being passed through a dilute alkaline solution before use. The dyeing should be begun cold, the temperature being slowly increased to 40° R; 15 to 20 grammes will dye a kilog. of goods. Silk may be dyed in the same way. *Reimann's Färberzeitung, No.* 36, 1874.

Detection of Cotton Fibre in Linens.—R. BOETTGER recommends to treat the fabric with an alcoholic solution of rosolic acid, and subsequently to soak in concentrated solution of carbonate of soda and caustic soda. Linen is thus tinted pink, whilst cotton fibres are unaffected. *Chem. Centr.* 1874, 379.

Jaune d'Or for Woollens.—Dissolve in boiling water, and add a little oxalic acid. Begin to dye cold, and subsequently heat to boiling. This colour may be used as a substitute for turmeric and fustic in modifying archil browns; if topped with magenta a fast shade is obtained bearing much resemblance to scarlet. 1 gramme of colour will dye a kilog. of goods. *Reimann's Färberzeitung, No.* 36, 1874.

Artificial Indigo on Wool.—For every 100 parts of goods, take five of colour, and add an equal weight of acetic acid; boil for two hours, and finish off with logwood if a dark shade is required. Clear in dilute sulphuric acid after dyeing. *Chem. News, xxx.* 197, *from Reimann's Färberzeitung, No.* 36.

Anti-Mildew Size.—R. K. WHITEHEAD renders the materials employed for sizeing yarn, woven fabrics, &c., proof against mildew by the addition of a little mustard oil, or other vegetable oil possessing antiseptic properties. About 4 ounces of oil to 1 gallon of size is usually sufficient.

Manufacture of Red Lead and other Metallic Oxides.—ORSAT patents the use of rotating furnaces furnished with internal partitions for the preparation of metallic oxides, especially the oxides of lead, massicot, minium, &c. Any kind of combustible may be used, especially the gases from gas generators; heated air may be employed to facilitate the oxidation. *Bull. Soc. Chim. Paris, xxii.* 334.

Galenite.—J. DAVID patents the manufacture of a new compound of lead, applicable to the purposes for which white-lead and red-lead are employed, and producing such compound from galena. In this invention galena is reduced to powder, and is oxidized at a low red heat in open retorts, and thus converted into a basic sulphate, which is then ground between millstones immersed in water. The liquid thus obtained is placed in vats; and the suspended matter is allowed to deposit, and is dried, constituting a new substance termed "galenite," which is applicable to all purposes for which red lead and white lead are employed.

§ 4. *Food, Water, and Sanitary Matters.*

Compressed Yeast.—J. V. DIVIS recommends to wash the yeast with a dilute solution of carbonate of ammonia, and after settling and drawing, to press into cakes, a little starch and ground malt being added. To facilitate settling cold water should be used, or alum may be added to the first washwater, the precipitate being subsequently well washed with pure water. *Chem. Centralblatt,* 1874, 288.

Detection of Picric Acid in Beer.—H. BRUNNER recommends to acidulate the beer with hydrochloric acid and then to digest in the waterbath with woollen yarn which becomes thereby dyed yellow; extractive matters are, however, taken up which alter the shade, giving a dingy brown yellow; the dyed wool may be treated with aqueous ammonia; the filtered liquor is concentrated to a small bulk and then treated with a little solution of cyanide of potassium; a red coloration is produced if any picric acid be present, the coloration being due to the formation of isopurpuric acid. A milligramme of picric acid in a pint of beer (1 part in 500,000) can thus be detected. *Arch. Pharm.* [3] *ii.* 343.

Valuation of Alcoholic Liquors.—DUCLAUX gives the following table for the valuation of alcoholic liquors by the dropping arrangement described in the "Practical Magazine," Sept. 1874, p. 229.

A pipette holding about 5 cubic centimetres which will deliver 100 drops when filled with water will give the following numbers when filled with dilute alcohol, the temperature being 15°.

Percentage of alcohol by volume.	No. of drops.	Percentage of alcohol by volume.	No. of drops.
1	107	19	173
2	113	20	176
3	118	25	192
4	122·5	30	204·5
5	126·6	35	216
6	130·5	40	225·5
7	134	45	235
8	137·5	50	243
9	140·5	55	247·5
10	144	60	251
11	147	65	253
12	150·5	70	255·5
13	154	75	257
14	157	80	258·5
15	160	85	259·5
16	163·5	90	261·5
17	167	100	270
18	170		

Analogous tables are also given for other temperatures. *Journal of the Chemical Society, xii.* 1012, *from Ann. Chim. Phys.* [5] *ii.* 233.

Purification of Water for Industrial and Domestic Purposes.—G. DEMAILLY adds to water containing bicarbonate of lime an equivalent quantity of caustic lime, when the second equivalent of carbonic acid in the bicarbonate leaves the latter, combining with the caustic lime, and thus precipitating as carbonate all the lime hitherto in solution as bicarbonate. The water containing the lime in suspension is passed into a filter consisting of a cylindrical vertical case of sheet or cast iron furnished with a lid; in this is contained another cylinder, which is the filter proper, also formed of sheet or cast iron, and between the two are arranged three concentric cylinders of perforated plates. These cylinders form two annular spaces, supplied with some filtering material, such as felt or wool rendered imputrescible.

The water arrives in the filter by a tap, and spreads itself in

the open space between the envelope and the filtering cylinder; then by pressure it traverses the latter, and makes its exit by a discharge tap perfectly clear and freed from all matters in suspension.

The filter supports a recipient for the lime united to a mixer, the supply pipe being connected by a tube to the recipient, and directly with its base to one of the orifices of the mixer, the other orifice being united by a tap to the entrance pipe. The apparatus works by pressure or by the aspiration of a feed pump, the purified water flowing into a reservoir or being directly conveyed by force to the generator. The recipient, in which the lime water is prepared, consists of a vertical cylindrical case of cast iron with a lid at the top; the liquid therein is directed to the bottom by an inner pipe. Within this case is another vertical cylinder formed of two cast-iron plates and two cylinders of sheet iron, the latter forming an annular space furnished with some filtering material and a pipe. The cylindrical filtering body forms part with the base of the recipient, and is locked top and bottom by an adjusting screw; at the base is a three-way tap, one of whose openings communicates with the recipient; another in the same axis puts the mixer and recipient in communication, and the third branches on the water supply of the generator. A discharge tap is fixed to the case.

The recipient contains a certain quantity of lime which dissolves in proportion to the water contained, and according to the continuous arrival of the water. The lime water thus formed flows by pressure through the filtering cylinder, and arrives in the central pipe perfectly clear and ready for distribution or mixing by a tap. The mixer consists of a bent wing wheel, terminating at the top by a screw; the wheel turns on an inverted pivot on a vertical axis, and is lodged in a cylindrical chamber perpendicular with the axis of the recipient and tangent to the common axis of the supply-pipe of the tap and tube of admission into the filters. Supposing this latter tap to be open, the water arriving by the supply-pipe enters the chamber, and meets in its passage the paddles of the wheel, which under the action of the current is animated by a rotatory motion of a speed in accordance with the flow.

The cleansing of the filter is effected, without the necessity of taking the apparatus to pieces, in the following manner: When the steam engine is stopped, the tap admitting water into the filter is closed, as well as the exit pipe communicating with the feed pump, which allows of free communication with the central pipe of the filter and water draught of the generator. On opening the discharge tap it will be seen what has taken place. The pressure of the generator sends the water already purified into the central pipe of the filter. This water traverses inversely the beds or layers of filtering matter, and draws along with it the foreign organic matter arrested during filtration, and flows out by the discharge tap.

The whole cylindrical body is movable on the pivot at its base, and communicates with the exterior by a shaft at the top furnished with a fly wheel, by aid of which the water imparts to the cylindrical filtering body a circular movement, the effect being to pass the external surface of the cylinder several times under the action of a brush fixed vertically at the inner side of the case, which suffices to dislodge any residue that might be adhering thereto.

[This arrangement appears only to effect the removal of the lime present as bi-carbonate, the sulphate of lime (which gives the permanent hardness) being wholly unaffected: the use of quicklime, as above suggested, is very well known and frequently practised; subsidence is usually employed instead of filtration, being much cheaper and equally efficacious, provided sufficient time be allowed. ED.]

Preservation of Food.—M. H. SMITH patents the use of aldehyde, either alone or in combination. The inventor causes the alimentary substances to be preserved in vessels in contact with aldehyde, and having impregnated the alimentary substances, the vessels containing the same may be closed.

Preservation of Food, &c. by Artificial Refrigeration.—E. D. NICOLLI and S. T. MORT propose the following method:—The substances to be preserved are first subjected to a temperature of about 60° below zero, and in hermetically closed vessels, by which means the germ or ferment is destroyed, and the substance, if kept from atmospheric air, will not ferment or putrefy, although the temperature may be raised. If desirable the interstices in the tins may be filled up with concentrated meat juice, gelatin, &c. The air may be removed by antiseptic gases, also cooled to the temperature necessary for destroying the germ or ferment in the meat. The agents preferred for producing the requisite cold are highly compressed air or gases, which are subsequently allowed to expand in pipes or around the meat-containing vessels; or the same result may be arrived at by the liquefaction and subsequent gasification of ammonia, as in the Carré ammonia machine and other analogous arrangements.

Preserving Ham and Bacon.—J. K. COLLETT employs pea-meal or flour of Indian corn for the packing of hams, bacons, &c. The meat to be packed is laid in layers into barrels or boxes, and well laid over with the flour. This latter may, on the unpacking of the hams or bacons, be used for animal food.

Filtration of Beetroot Juice.—DEHNE uses large filtering presses, where the filter-cloths are replaced by perforated iron plates; the holes speedily become partially plugged by the beetroot fibres, &c., so that a vegetable filtering bed is formed, through which the juice runs very rapidly and quite limpid: two men can thus treat 3,000 quintals of beetroots in a day. *Bull. Soc. Chim. Paris, xxii.* 336.

Tobacco.—H. W. HAMMOND patents the following process for separating nicotine and ammonia from tobacco:—Steam is allowed to pass through a hermetically closed vessel to soften the tobacco, when by means of Bequereux' air-rarefaction apparatus connected with the vessel, all the nicotine, ammonia, and air are extracted from the tobacco and the vessel containing it. To give to the tobacco an agreeable aroma, extracts of either of the following ingredients are added to each hundredweight of tobacco, viz. (*a.*) 8 litres of water, 2 litres of beer, ½ lb. of green tea, ½ lb. of ground plum kernels, 10 grammes of fine honey, 5 grammes of rose leaves, 1 gramme of vanilla, 6 grammes of peppermint, 1 lb. of juniper berries. (*b.*) 10 litres of water, 2 grammes of cardamoms, 3 grammes of ginger, 2 grammes of lavender flowers, 2 grammes of galangel, 2 grammes of reseda oil, 25 grammes of currants, 50 grammes of plum kernels, 1 lb. of juniper berries. (*c.*) 10 litres of water, 2 grammes of cardamoms, 3 grammes of ginger, 2 grammes of lavender flowers, 2 grammes of galangel, 2 grammes of reseda oil, 25 grammes of currants, 50 grammes of plum kernels, 1 lb. of juniper berries. These prepared ingredients are allowed to simmer with the tobacco for three hours, when the tobacco is taken out of the vessel, dried, and made ready for use.

Injurious Action of Sulphurous Acid on Vegetation.—ANGUS SMITH (inspector under the Alkali Act) states that this Act requires extension and greater stringency in order that the public wrong against which it is levelled may be effectually dealt with. In Germany, where the same evil exists, much good has been accomplished by legal enactments; and it has been found there, as elsewhere, that it pays to retain the sulphurous vapour, transforming it into sulphuric acid. It has been found, indeed, that there is no other remedy; for when the furnace chimneys are carried higher, the fumes only go further, increasing the area of damage, and, besides, by the increased draught more metalliferous dust is carried into the atmosphere. Careful investigations relative to the effect of acid vapours on vegetation have been conducted in Germany, and it has been found that sulphurous acid is pernicious to plants when it exists in the air to a greater extent than one part in 200,000 or 300,000 parts, and is much more detrimental than arsenious acid. Speaking of the effect of the vapours from the Freiburg works, where zinc, copper, and lead are produced, arsenic and sulphur being present in the ore, Freytag says that the leaves of plants exposed to their influence die before their time, the cereals vegetating for a time, but bearing no grain. Stoeckhardt says that herbs, turnips, beetroot, kohl-rabi, dahlias, and all plants with strong leaves, suffer in a lesser degree. Fruit trees under such an influence seldom give any fruit, even in a good year. He observed that the trees which were much exposed were stripped of their leaves. A plant has been known to wither in two hours when there has been only a one-thousandth part of sulphurous acid in the air; and the effect was yet striking when the proportion was nine times less. With as little as one ten-thousandth part of acid in the air, the leaves of plants have been destroyed in forty-eight hours, without, however, quite killing the plants. Angus Smith says, "The air of Manchester will allow no plants to grow." From his own observation, he is able to believe in the slow dying of trees after several years of exposure to air with acid gases in it to an extent much smaller than what a chemist would probably call "a mere trace." The air of Manchester contains acid, and hence the plants will not grow. Yet the rain of Manchester contains no more acid than the eighty-thousandth part. This is a proportion called "incredibly small," and yet it is large compared to that found at a distance from the town, where, nevertheless, the vegetation is not perfect. *Iron, No.* 93, 517.

Deodorizing Materials.—F. T. BOND patents the combination of certain metallic and other matters, especially the sul-

phates or chlorides of aluminium, iron, or copper, with sawdust, so that the latter shall be saturated therewith. For certain purposes the oxides of the said metals are precipitated in and upon the sawdust, by treating it when saturated with the said salts, with ammonia, or with carbolic acid.

Artificial Manure.—W. CROOKES patents the following method of treatment of waste animal or nitrogenous matters, for the purpose of producing fertilizing substances or artificial manures. Fish, flesh, or other putrescible organized matters, are chopped up or otherwise finely divided, and then steeped in any convenient liquid possessing antiseptic, deodorizing, or disinfectant qualities, or sprinkled over with such a liquid; the liquid portion of the mass is then separated from the solid by means of a hydro-extractor.

Utilization of Animal Excreta.—L. HESSE patents an improved method for the deodorization, disinfection and utilization of human and animal excreta. According to this system, the matters to be treated are first agitated, so that the fluids and solids may be intimately mixed together. The whole is then conveyed into a closed vessel or boiler, and heated until the ammonia is drawn off, after which the residue is further subjected to heat until it is of about the consistency of dough, when it is transferred to the drying chamber. The vapours issuing from the drying chamber are conveyed to the furnace and there burnt. The ammoniacal vapours are made to pass through some substance capable of absorbing them. Any of the ammonia not absorbed is also made to pass through and be burnt in the furnace. In treating urine, 1 per cent. of lime is first added and the mixture heated, until all the ammonia is evolved. The residue is then withdrawn, the supernatant liquor drained off, and the precipitated matter retained and dried.

Material for Earth Closets, &c.—MAXWELL LYTE patents the use of a mixture of mineral phosphates or coprolites, and turf, saw-dust, tar or dried blood, fæces, &c.; the whole is then formed into brick-shaped masses, and calcined; when pulverized, the resulting substance can be used instead of animal charcoal for various purposes, such as the disinfection of urinals, privies, stables, &c. *Bull. Soc. Chim. Paris, xxii.* 236.

Action of Earth on Organic Nitrogenous Matter.—E. C. STANFORD finds, that whereas charcoal, when mixed with organic nitrogenous matters (*e.g.* fæces, &c.), does not cause any loss of nitrogen either as ammonia or by the formation of nitrates; ordinary loam rapidly causes the production of ammonia, so that after keeping for only a few weeks, a large amount of nitrogen is thus lost. He concludes from his experiments that earth mixed with organic nitrogenous matter is an indifferent drier and a poor deodorizer (unless used in very large quantity), and that such mixtures continuously lose nitrogen to the extent of about 73 per cent. in five months, the nitrogen not being converted into nitrates by oxidation, but being lost apparently as ammonia. *Chem. Soc. Journal* [2], *xii.* 938.

§ 5. *Fuel, Gas, Illumination, Photography, &c.*

Artificial Fuel.—WEBER states that a fuel can be readily prepared from charcoal dust, which will possess the following qualities:—It is very light, burns slowly, and is not extinguished by limiting the air supply. Pulverized charcoal, coal, nitre, and paste are mixed together, and the damp mixture strongly compressed into bricks. The fuel thus produced is suitable for use in stoves, furnaces, &c., in waggons, railway carriages, and the like, where no great amount of heat is requisite. A specially constructed stove is required, resting on a support of thick wire basket work, placed under the seats, suitable arrangements being made for carrying off the vitiated air by pipes. These charcoal bricks also answer well for burning in new houses for the purpose of drying and carbonating the fresh plaster on the walls, ceilings, &c., no smoke being generated. *Dingler's Polytech. Journ., ccxi.* 486.

F. PAGE patents the following process for the preparation of artificial fuel from culm or coal dust and apparatus to be employed in the moulding of such artificial fuel. The inventor mixes clay, lime, peat, starch, potatoes, or potato matter, nitrate of potash, carbolic acid, and Condy's fluid, or some of these substances, with the culm or coal dust, and incorporates the mixture in a mortar mill. He uses a cylindrical hand mould with a sliding piston to mould the fuel.

Peat Fuel.—J. IMRAY patents the following process for the preparation of peat for fuel or charcoal. The peat is put into moulds arranged round the periphery of a revolving wheel or ring; each mould being fitted with a piston and provided with a cover, both of which are porous and clothed internally with hair cloth. The pistons and covers have rollers which bear on guide-rails, by which they are moved as the wheel or ring revolves; the pistons being made to ascend and descend in the moulds, and the covers to fold back and to close over the moulds. At one part of their course, the covers being folded back and the pistons descending, the moulds pass under a hopper charged with pugged peat, with which they are filled. The covers are then closed down, and the pistons are made to ascend and compress the peat, moulding it into blocks which, when the covers are opened, are extruded by the farther ascent of the pistons, and are guided off the apparatus. The strain of compression, while the pistons are ascending, is taken off the wheel or ring by rollers running along the under surface of a guide rail. The blocks are afterwards dried and seasoned.

Composition of Various Kinds of Wood.—G. W. HAYES gives the following analyses of the wood of various species of acrogens, mostly collected near New Haven. The last four analyses in the table are given by WEBSKY and PAYEN:—

	Carbon.	Hydrogen.	Nitrogen.	Ash.
Lycopodium dendroideum	47·11	6·39	1·40	3·25
„ complanatum	45·78	6·25	1·84	5·47
Equisetum hiemale	41·94	5·89	1·12	11·82
Aspidium marginale	44·77	5·99	2·08	5·19
Cythea caniculata (section)	45·39	6·11	1·12	7·56
„ „ (cortical part)	48·72	4·89	1·42	6·49
Sphagnum (plant of peat swamps)	49·88	6·54	1·16	—
Oak	50·00	6·20	—	—
Beech	49·25	6·10	—	—
Ebony	52·85	6·00	—	—

Chem. Soc. Journ. [2], *xii,* 1000, *from Amer. Journ. Science* [3], *vii.* 585.

Coking Coal under Pressure.—E. T. COX states that when coal is coked under increased pressure, there is a much larger yield of coke than is produced under the ordinary atmospheric pressure; thus the following figures illustrate the different results obtained under different degrees of pressure with 6 varieties of coal:—

No.	Platinum Crucible. Proximate Analysis.	Iron Retort. No Mercury.	Iron Retort. 3 inches of Mercury.	Iron Retort. 6 inches of Mercury.	Iron Retort. 12 inches of Mercury.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	52·40	59·10	62·00	62·80	59·40
2	57·90	65·05	65·00	65·10	66·10
3	58·50	62·20	61·75	62·60	63·40
4	57·50	58·85	60·40	58·50	59·25
5	52·50	54·35	54·00	54·30	56·50
6	55·50	56·10	56·40	57·95	56·15

The first column contains the per cent. of coke as determined by proximate analysis. The second column the per cent. obtained in a small iron retort without pressure. The third column contains the per cent. when the gas escaped from the retort under a pressure of a column of mercury 3 in. high; the fourth under a pressure of 6 in. of mercury; and the fifth under a pressure of 12 in. of mercury, or a little more than one-third of an atmosphere.

The coke obtained under pressure is usually much harder and denser than that produced in the ordinary way. Bituminous coal thus treated gives a coke resembling anthracite more closely than ordinary coke, whilst dry burning coal can be made into a strong and dense coke.

By covering coal with a layer of sand an inch thick, and permitting the gases to escape through this, the density and strength of the coke is materially increased. *Iron, No.* 92, 491.

Weather Waste of Coal.—It is a known fact that coal when exposed for a long time to the influence of air, sun, or moisture, loses a certain quantity of its heating value, undergoing a kind of slow combustion. Highly bituminous coal also loses a part of its carburetted hydrogen, which escapes as gas and very often causes explosion in coal ships, when the hold has been held closed for a long time and is incautiously approached with a burning candle. The alteration of exposed coals differs, of course, very much according to their original quality. The German Railway Association have exposed to the air for twelve months several kinds of coals, and find the following amounts of loss:—

	Weight. per cent.	Calorific. per cent.	Yield of Coke. per cent.
Pease's West Hartley coking	0·0	0·0	0·0
Glucksburg seam, Ibbenburen	1·4	6·0	4·6
Carl Mine, near Dortmund	0·0	2·6	2·1
Hibernia Mine, Gelsenkirchen	0·4	0·6	2·1
Constantine Mine, Bochum	0·4	0·4	0·0
Borglohe Mine, Osnabruck	2·0	6·0	0·5

These figures would prove that the loss sustained in weight, calorific power, and yield of coke, though appreciable after one year's exposure, are, in most instances, not so great as to counterbalance the profits arising out of laying-in stocks at a convenient time.

Wax.—C. MENE states that beeswax is often adulterated with a substance known as "Japanese wax," largely imported into Havre and Bordeaux, and selling at 1·75 to 2 francs per kilog. (about half the price of the genuine article). Genuine beeswax has the sp. gr. 0·96931, and melts at 64° to 65°; Japanese wax has the sp. gr. 1·00200, and melts at 52° to 54°. All mixtures of the two have, however, a lower sp. gr. than either of the components, whilst the melting point is but little different from that of pure beeswax; thus the author gives the following numbers:—

Percentage Beeswax.	Composition Japanese wax.	Sp. Gr.	Melting point.	Solidifying point.
0	100	1·00200	52-54	45-46
100	0	0·96931	64-65	63-64
50	50	0·93518	64-65	61-62
40	60	0·92785	64-65	61-62
35	65	0·90730	64-65	61-62
30	70	0·90452	63-64	61-62
25	75	0·90164	63-64	62-63
20	80	0·88703	63-64	62-63
10	90	0·85100	63-64	62-63

Comptes Rendus, lxxviii. 1544.

Manufacture of Gas.—W. WRIGHT impregnates atmospheric air with some hydrocarbon purified by distillation with vegetable charcoal. The apparatus in which the impregnation takes place consists of several air-tight cylinders with pipes communicating from one to the other. Each cylinder is filled to near the top with a series of stationary pistons formed of cotton or other similar fibrous material admitting of air being forced through them. The cylinder has also at the bottom a reservoir for containing the prepared hydrocarbon with which the pistons become charged by reversing the cylinders, which for that purpose are mounted on two swivel joints; these joints act also as two taps for closing simultaneously all communication with the inlet (air) and outlet (gas) pipes. The reservoir is separated from the pistons by a perforated plate. At the bottom of each reservoir is a tap, which communicates with a pipe and tap belonging to the next cylinder, so as to equalise the supply of spirit in each reservoir. The air under pressure enters at one of the swivel joints through a valve, and passes into the first cylinder under the perforated plate, and thence upwards through the series of cotton pistons and out of the cylinder at its upper part, from here by a communicating pipe into the bottom of the next cylinder, and so on, until it reaches the swivel joint on which the last cylinder is mounted, and passes from thence in the form of gas to the burner.

The air is forced into these impregnating cylinders by especially constructed aerometers; but it may be effected by any of the known air-forcing means.

Purification of Gas and Gas Liquor.—F. C. HILL patents the following process:—The crude gas liquor is run either direct or through a scrubber to a still in which the liquor is kept at a temperature of about 180°, whereby carbonic acid, sulphuretted hydrogen, and ammonia are driven off. These products pass from the still up through the scrubber, the greater part of the ammonia being condensed and carried back to the still by the descending gas liquor, when the liquor is passed through the scrubber, while the sulphuretted hydrogen and carbonic acid gases escape at the upper part of the scrubber with a little ammonia, which latter may be taken up by water, acid, or other suitable agent. The carbonic acid and sulphuretted hydrogen may be passed through oxide of iron to collect the sulphur. The crude gas liquor before being run into the still may be kept for some time at a temperature of about from 160° to 170°, and the sulphuretted hydrogen then given off may be used for making sulphide of lime or sulphide of ammonium. The gas liquor treated as described may be used for purifying gas. Crude gas liquor is made to combine with the carbonic acid present in the gas, and thus to free the gas from such acid, by passing the gas direct from the hydraulic main at a temperature of about 160° into a scrubber.

Utilization of Gas Lime.—G. H. FORBES patents a process consisting in the subjection of the refuse lime of gas-works to the process of dry or destructive distillation in a retort, and passing the volatile products of distillation through water into a receiver for the purpose of condensing the vapour of sulphur. The gases that remain may then be passed through oxide of iron. The material obtained by burning the products is afterwards applied to the purpose of purifying gas.

Valuation of Anthracene.—R. LUCAS gives the following comparison between the results obtained by the "bisulphide of carbon test" and the "anthraquinone test" (*vide* "Practical Magazine," June, 1874, p. 437).

PERCENTAGE OF ANTHRACENE.

Bisulphide test.	Anthraquinone test.	Difference.
9·2	11·9	+2·7
16·0	16·4	+0·4
24·5	26·1	+1·6
34·0	27·8	—6·2
35·0	28·2	—6·80
38·0	29·67	8·33
38·0	33·38	4·62
40·5	38·0	2·50
43·0	33·8	9·20
49·0	34·24	14·76
57·4	44·51	12·89
58·0	41·50	16·5
59·0	44·51	14·49
59·5	39·37	20·13
60·0	37·66	22·34
60·0	42·80	17·20
64·12	48·79	15·33
65·0	47·08	17·92
67·0	46·22	20·78
73·0	49·22	23·78

When the bisulphide test is employed, great errors are introduced by the circumstance that a considerable amount of anthracene is dissolved by the solvent, whilst a large quantity of other substances is left in the undissolved anthracene: thus, according to the author, from a quarter to one-third of the anthracene is dissolved, whilst the insoluble portion only contains from 50 to 60 per cent. of its weight of pure anthracene.

In some cases 10 grammes of chromic acid are not sufficient to oxidize all impurities, when the anthraquinone test is used; with 15 grammes, and after boiling for three hours, pure anthraquinone is always obtained. *Chemical News, xxx.* 190.

Photographic Pictures by means of Platinum and Iridium Salts.—WILLIS proposes to employ compounds of platinum and iridium as sensitive agents for the photographic reproduction of pictures. The paper is soaked in a solution of platinochloride of potassium (1 part to 48 of hot water) and then dried; it is then soaked in lead nitrate solution (1 part to 12 of water), and again dried; finally it is soaked in solution of iron oxalate (1 part to 8 of water) containing a little free oxalic acid, and again dried. After exposure under a negative, the picture is washed with hot solution of oxalate of potassium, then with weak oxalic acid solution, water, hyposulphite, and water, in succession.

Or the paper treated with the platinum compound is soaked in silver nitrate solution (1 to 60 parts of water), and after treatment with oxalic acid, is dipped into a strong solution of ammonium chloride, or weak ammonia liquor.

Platinum bromide solution (1 part to 40 of water) may be employed instead of potassium platinochloride; after drying, the paper is soaked in ferric-tartrate solution and dried. After exposure, the picture is floated on hot potassium oxalate solution to develop, and then dipped into weak oxalic acid solution, washed and dried. *Chem. Centralblatt,* 1874, 583.

Photography.—PAUL proposes to use albumin instead of gelatine in the bichromate process; a finer and more delicate picture is thus produced; cold water is used to dissolve off the unaffected part, a paper being chosen like that of the Autotype Company, which has an ivory-like smoothness and is unaffected by cold water. *Chem. Centralb.* 1874, 471.

New Photographic Printing Process.—W. WOODBURY proposes to coat metal plates with a solution of gum, glucose, and bichromate of ammonia; when plates thus treated and exposed in the camera are breathed on, different degrees of

stickiness result, so that when powdered glass or emery is sprinkled over the plate of three degrees of fineness (the coarsest being applied first and the finest last), the larger particles adhered to the more viscous surfaces and only the smaller ones to the less sticky portions, the latter being the points where the light has acted most. The plate is then exposed to light to harden it; an impression in soft metal is then taken; from this an electrotype can be taken possessing the grain requisite for copperplate printing. *Chem. Centralb.* 1874, 236.

Boiler Incrustations.—F. FISCHER finds that the nature of boiler crust depends not only on the nature of the water used but also on the pressure: thus sulphate of lime is deposited as hydrated crystals below about 126° and in anhydrous masses above that temperature. The higher the pressure the more sulphate of lime accompanied with carbonate is thrown down. Thus the following figures are given:—

	3 atmospheres.	1½ atmospheres.	After blowing off steam.
Sulphate of calcium . .	0·885	1·136	3·028
Chloride „ . . .	1·008	—	—
„ magnesium	3·479	0·189	0·769
Sulphate of sodium . .	—	0·104	5·161
Chloride „ .	4·743	0·478	9·582
Residue on evaporation	7·210	—	18·864

Chem. Soc. Journal [2] *xii.* 1021, *from Dingler's Polytech. Journal, ccxii.* 208.

Photography as an Adjunct in Wood Engraving.—T. C. ROCHE covers the blocks of wood with a layer of gelatine solution of the following strength:—

Water	31 grammes.
Gelatine . . .	0·39 „

using a soft brush; a coating of the above solution is then applied in the dark after the gelatin is dry.

1. Potassium ferrocyanide .	7·8 grammes.
Water	62·2 „
2. Ammonio-citrate of iron .	9·1 „
Water	62·2 „

These liquors are mixed and filtered before application; the mixture should be kept in the dark. The press and blocks are exposed under the negatives from 10 to 12 minutes, and then washed with a soft sponge; the design then appears in blue. Coatings thus prepared do not shell off under the graver. *Chem. News, xxx.* 197, *from Les Mondes, No.* 4.

§ 6. *Miscellaneous.*

Strength of Glass Tubes.—M. CAILLETET has found that a tube of thin glass 20½ in. length and ½ in. in diameter was crushed by an exterior pressure of 1,155 lbs. to the square inch, while similar tubes were burst by an interior pressure one half less. In making use of very thick glass, capable of resisting a pressure of 400 to 500 atmospheres, he found the glass to sustain no permanent change. Upon this fact the construction of a very sensitive and simple manometer is proposed. *Mon. Scient.*

Enamel for Watch Faces, &c.—J. H. ROBINSON prepares these plates with a backing of sheet iron having raised edges to receive the enamel in powder, which is fused; after cooling, the lettering and figuring is printed on the plate with soft black enamel by transferring, the plate being then again placed in a muffle to fuse the enamel of the lettering or figuring. The enamel used is composed of white lead, arsenic, flint glass, saltpetre, borax, and ground flint, reduced to powder, fused, and formed into cakes, and ground up for use.

Soldering Platinized Glass.—W. C. RÖNTGEN states that the platinized glass must be well cleaned and warmed to prevent cracking; it is then tinned with the soldering iron after moistening with chloride of zinc, and can then be soldered to any metal. The tool must not be rubbed too much against the platinum coating, otherwise it becomes too much alloyed with the solder, and the adhesion to the glass is weakened. *Chem. News, xxx.* 187, *from Repertorium für Experimental-Physik, Band x.*

Artificial Stone.—J. NOYES patents the following improvements in the manufacture of artificial cements and stones. (1) The combination of cement, sand, or other suitable mineral substances or material, and an aqueous solution of gum copal to form a compound for making artificial stone and concrete, or for other purposes; (2) in the manufacture of the artificial stone, concrete, or similar material, the use of an aqueous solution of gum copal; (3) a process for manufacturing or producing an aqueous solution of gum copal by boiling gum copal in soft water, and adding thereto subcarbonate of soda or caustic soda or other alkaline substance.

Asbestos.—G. CLEGHORN and F. G. PATERSON patent the following applications of asbestos:—(1) Making paper out of asbestos fibre pulp, or a mixture of that with other fibre, and cutting this asbestos paper into strips, and twisting these into thread, yarn, or cord, either with or without being first coated with india-rubber; (2) twisting two or more of these into larger cords, either with or without a core of india-rubber, for making fluid-tight packings and joints of stuffing boxes, working and other parts of steam engines and other machinery, pipes, boilers, stills, and retorts; (3) plaiting these twisted asbestos threads into braids for making the said packings and joints; (4) weaving the asbestos thread or yarn into a cloth, somewhat about the texture of canvas, which would withstand the action of the weather and heat, and be used for flange joints and for coverings, mail and despatch bags, window curtains, also for producing works of art upon surfaces to stand against decay and fire, and making wrappers for projectiles; (5) making waddings, cartridge cases, and wrappers for cartridges out of asbestos paper, millboard, pasteboard, or woven fabric, which would prevent windage and friction, from the flexibility and lubricity of the asbestos enabling the barrels to be kept longer clean and be fired oftener.

Apparatus for Saturating Liquids with Gases, &c.—UNGEREZ employs a tower or a well, at the top of which is a tank to contain the liquid; the bottom of this is perforated with holes, through which pass ropes or iron rods, so that a large surface is exposed to the gaseous atmosphere in the tower as the liquid trickles down. By using hot air this arrangement can be adapted to evaporations; the solid residues are readily separated by raising and cleansing the ropes, &c. The air charged with the vapours escapes through holes in the sides of the tower near the top. *Bulletin Soc. Chim. Paris, xxii.* 335.

Bottling Aerated Waters.—E. BREFITT makes the bottle's mouth in the shape of an inverted truncated cone, through which he forces by compression a ball of yielding material or a plug and flexible washer or cover, either of which is held up by the pressure of gas from within. A combination of glass and other material of light gravity that will float the glass on water, into the lower portion of which is inserted a plug of glass which is kept up by the lighter substance, and by the pressure of the gas from within keeps the bottle's mouth closed. To empty such bottles a tube is used, the upper portion of which is surrounded by a flexible washer, which closes the space between the outside of the tube and the inside of the bottle's mouth. This tube has lateral openings at its lower part, and while the ball remains depressed by the tube, the liquid flows through the tube, while on being removed before the bottle is entirely emptied, the ball returns to its position as a stopper.

Carboleum.—BEINS gives this name to liquefied carbon-dioxide, which he considers to be eminently suited for use as a motive power. At a temperature of but little above 100° C. (boiling brine) the gas or vapour of this fluid evolved in heating a solution of bicarbonate of soda exerts a pressure of about 4-5 atmospheres and at 300° C. the tension is 50 to 60 atmospheres.

A litre of carboleum at 15° C. and with a pressure of 50 atmospheres weighs approximatively 0·8 kilogs. and will produce 400 litres of carbonic acid at the ordinary pressure. The power required to produce compression to the extent of 50 atmospheres is equal to about 17,000 kilogrammetres. This gives 270,000 kilogrammetres per hour and per horse-power, for 16 litres of carboleum at 50 atmospheres and 15° C.

It is only when a carboleum engine works with large intervals between, that the heat of evaporation can be carried to the sides without heating artificially. In the majority of cases the carboleum must be evaporated by the artificial heating of small quantities at a time. The heat required per horse-power per hour, as already given, namely, 270,000 kilogrammetres. is equal at least to 640 calories (0·1 kilog. of coal).

Large carboleum engines should be worked with regeneration. They should have a depot of salt of soda and carboleum, so arranged that the decomposed bicarbonate shall be regenerated by the carbonic acid which has worked the engine. Such a machine transforms very advantageously into mechanical power the heat supplied by the fire to decompose the bicarbonate constantly regenerated. Supposing the gas to act at the temperature of 100° C., the 16 litres of carboleum necessary per horse-power per hour will be reduced to 10 litres. Such an engine requires about 0·3

kilogs. of coal per horse per hour, while the best constructed steam-engine consumes 1·2 kilogs. to 1·9 kilogs.

For ships, the weight of an engine of 100 horse-power, with fuel for 240 hours, will be one-fifth less than that of a steam-engine of equal power. And as several parts of a carboleum engine require to be more massive, it will take up less room.

Carboleum engines are not liable to explosion, and the metal-work is not attacked, provided moisture be absent. When a small amount of motive power is wanted at intervals, carboleum promises to be extremely convenient, being ready to act at a moment's notice. For submarine vessels, production of electric light, &c. &c., it is eminently adapted. *Iron, No.* 93, 530.

Incrustation of Boilers.—If lumps of metallic zinc are placed in the boilers, the zinc gradually becomes corroded, probably by galvanic action with the iron. No scale, however, is deposited, but the insoluble bodies found during evaporation are left in the pulverulent form : the discovery of this circumstance was due in the first case to accident.

One of the engineers on board the transatlantic steamer "Saint Laurent," accidentally left in the inside of his boilers an ingot of zinc before his departure from Havre. Upon his return, proceeding to examine his boilers and remembering his forgotten ingot of zinc, what was his surprise to find no scaly deposit whatever on the heating surface of the boiler, and further, no trace of the zinc ingot. Thinking, on consideration, that the zinc might have prevented the formation of the scale, he again placed in the inside of the boiler an ingot of zinc weighing 80 kilogs. On after examination, he found the phenomenon repeated, the zinc disappearing, and no scale being formed, the only residue being a black mud at the bottom of the boiler, easily washed out. This incident was repeated to the user of a boiler of 20 horse-power at Angers, who used the water of the Loire. He then inserted some kilogs. of zinc turnings, and found that the disappearance of the zinc was in his case as effectual as in the case of the salt water, in preventing the formation of any scale on the heating surfaces. *Iron, No.* 95, 589.

Electric Fuses.—C. A. Mc EVOY manufactures electric fuses in the following manner :—The end portions of two metal wires are connected together by casting round them melted sulphur, to which powdered glass, sand, or plaster of Paris has been previously added. The ends of the wires passing from one end of the sulphur casing, and which are to be coupled with a battery, are coated with some insulating material ; the ends of the wires projecting from the opposite end of the casing are connected by a thin wire of platinum. On sending an electric current of sufficient strength through the wires, the platinum wire will become red hot. The end of the sulphur case, containing the platinum wire, is inserted into the interior of a fulminating box, etc.

Animal Charcoal.—J. DENTON patents the use of a peculiar apparatus for treating animal charcoal for the purpose of re-burning or re-vivifying it. This consists of a kiln with cylindrical retorts of fire-clay which may be glazed internally. They should be set in horizontal rows and be connected together by shoots through which the charcoal may pass from the upper to the lower retort. Each retort is fitted with a cover at each end, the receiving end having an opening at its bottom side for discharge. In each cover, or in the covers of one of the rows, there should be a bearing for receiving a revolving spindle, and within each such retort and supported in the bearings of the covers, is mounted a revolving shaft, and upon this shaft is mounted a series of arms, spirally, for the purpose of moving the charcoal along from the back to the front end of the retort and delivering it thence to the cooler, which may be an Archimedean screw working within a trunk. Through the hollow perforated revolving axle within the retort may be drawn by exhaustion the vapours given off from the charcoal. Instead of the hollow and perforated revolving axle and the exhausting apparatus, superheated steam may be driven through the axle, so as to mix with the vapours. Within the flues, coils of pipes for generating steam and heating air are placed, and coils of water-circulating pipes are fitted to be used in connection with the washing and purifying apparatus. In conjunction therewith, vessels are arranged for washing and purifying the charcoal, in which the water is kept at a high temperature by the circulation of hot water within a coil of pipes. Each vessel has an agitator fitted therein, consisting of a hollow shaft with hollow radial arms ; and hot air or steam generated in the flues is blown through it.

Colour Printing.—W. M. HALBERT patents the use of papers of any of the various colours for the printing of newspapers and books from the ordinary types or stereotyped plates, with any other coloured inks or liquid dyes which would contrast with the colour of the paper ; the letterpress being printed with the complementary colour, namely :—On a red paper the letterpress is printed in green, and *vice versa ;* on a blue ground the letterpress is printed in orange, and *vice versa ;* on a yellow ground the letterpress is printed in violet, and *vice versa ;* on a violet red the letterpress is printed in yellowish green, and *vice versa ;* on a violet blue the letterpress is printed in orange yellow, and *vice versa ;* on a greenish blue the letterpress is printed in reddish orange, and *vice versa.* As equal proportions of the three primary colours can produce white, black is complemental with any of these colours ; therefore black grounds are used for printing with any of the other coloured inks or dyes, or *vice versa.* The letterpress may also be printed on the coloured grounds with acids, which would extract the colour from the paper and leave the letterpress white.

India-Rubber Solution.—Caoutchouc is well washed with water to remove dirt and then cut under water into slices about a centimetre thick ; these are pressed between rollers, and the thin sheets thus produced torn into strips and dissolved in the mixture of benzol and turpentine in the following proportions :

India-rubber	26 parts
Benzol	50 „
Turpentine	70 „

The solvents must be free from dissolved grease. Lampblack or other colouring matter can be added if required. *Chem. Centralblatt*, 1874, 16.

Varnish.—M. ZINGLER patents the following process, consisting in dissolving camphor in bisulphide of carbon, mixing the solution with powdered gum copal, or other hard gum, and afterwards adding either camphor or methylated spirit or both. After the materials have been thoroughly agitated until the whole of the gum is dissolved, the product is a spirit varnish. Oil varnish is produced by dissolving linseed or other drying oil in camphor or in methylated spirits or in a mixture of these ; and this compound is mixed with the spirit varnish above described. With these spirit and oil varnishes can be mixed other gums or resins.

SELF-PROPELLING STEAM FIRE-ENGINES.

STEAM engine No. 32, of the New York city fire department, stationed at Burling Slip, is provided with a very simple device which adapts it perfectly for self-propulsion. On one end of the crank shaft operated by the steam cylinders, and outside of the heavy fly wheel, is secured an iron flanged pulley, the periphery of which is corrugated. In line with this, on the rear axle and inside one of the rear wheels, is a similar though larger pulley, to which power is communicated from the one first mentioned by means of a strong endless chain. This is the only point of difference between this engine and that of the ordinary form drawn by horses. In fact, by merely removing the chain and attaching the pole, animals can be at once harnessed to the machine. The working of the steam cylinders of course propels the rear wheels, and a man in the driver's seat governs the ordinary hand steering wheel, and so directs the apparatus.

This engine weighs about 8,500 lbs., and is of great power ; and since it would be a heavy load for two horses, the device above described has been fitted to it. It travels at a speed about equal to that of the moderate trot of a team. *Scientific American.*

INTERNATIONAL EXHIBITIONS FROM 1851 TO 1874 : A RETROSPECT.

WE have now reached a point in the history of industrial progress when it may be well to pass in review the proceedings of the last twenty or thirty years, so far as they have been marked by the holding of International Industrial Exhibitions in various countries, especially England and France. We have just witnessed the sudden collapse of a scheme brought forth under high auspices, the humiliating failure of the Annual International Exhibitions in London at the end of the fourth year of a series which was to have continued for ten years, or perhaps longer. Opinions differ as to the cause or causes of this *fiasco*, and are likely to differ until all the surrounding circumstances are taken into account. A glance at the earlier International Exhibitions will be desirable, to show how they arose

out of strictly National Exhibitions, and how they led to the recent annual displays.

The annual displays only would not suffice to determine those surrounding circumstances. We must also compare the Exhibitions in London with those held in other cities or towns; the Exhibitions in the United Kingdom with those in foreign and colonial countries; the Exhibitions that are merely national with those that are international, or open to the contributions of all nations; and the Exhibitions that are confined to industry with those that embrace fine art as well as manufacturing art. To treat all these matters, however, with equal fulness, would require a volume rather than a few pages. We shall therefore confine our retrospect chiefly to English and Irish International Exhibitions, touching lightly on others that were national without being international, and on those which were held in foreign countries.

The Precursors of International Exhibitions.

It would not be possible to name a date when National Industrial Exhibitions first began; because they grew by insensible stages from germs too small to need notice. One thing we know, that they attained a considerable degree of importance earlier in France than in England. Three-quarters of a century ago an Exhibition of French industry was held at the Maison d'Orsay, Paris, under the auspices of the Marquis d'Avèze; it was a borrowed collection, without completeness or system, but the Parisians visited it with manifest pleasure, on account of the tasteful and beautiful articles which it contained. A second Exhibition, of improved character, was held in 1802; a third in 1805; and hence arose the custom of holding such displays triennially, continued with little interruption for half a century. All the specimens exhibited on these occasions were French, and mostly Parisian; they comprised a few of the rougher and more common articles fitted to supply the everyday wants of the mass of the people; but their main attraction to the visitors was in the beauty of the *articles de luxe*, for which Paris has so long been famous.

The attempts in the United Kingdom of a similar kind were few and far between, evincing neither unity of plan nor precision of object. One of the earliest worthy of mention was in 1829, and (to its credit be it said) was due to Ireland instead of to England, to Dublin instead of London. The Royal Dublin Society held an Exhibition of Irish industry at their rooms, and continued the practice triennially for some time. The Society of Arts in London, laudably desirous of advancing arts, manufactures, agriculture, and commerce in every practicable way, founded exhibitions occasionally, in most cases relating to mechanical inventions, but sometimes embracing a wider range. The Cornwall Polytechnic Society worthily laboured in the same direction, by holding periodical exhibitions to illustrate the mineral wealth of that county, and the mechanical appliances for mining, ore dressing, smelting, &c. It was a happy thought to imitate in towns the example thus set by a county: viz. that of illustrating the industries for which a district is mainly distinguished, and by which it thrives. Manchester did this, in regard to everything that concerns the cotton manufacture; Liverpool, in the raw produce of the whole world brought to that wonderful *entrepôt*, and the shipbuilding that renders such commerce possible; Leeds, in the two-fold series of industries that bear upon the flax and woollen manufactures; Birmingham, in the truly inexhaustible variety of useful and ornamental forms into which metals are wrought; and so of other towns. One particular exhibition at Birmingham, in 1849, was universally regarded as the most important thing of the kind ever projected and carried out in this country; on account of the care taken to render it really an industrial display, instead of partly a medley of museum curiosities; and equally on account of the care taken to set forth worthily those articles in which artistic taste claimed companionship with technical skill.

It was the exhibition just adverted to that gave the impetus, the energy, the earnestness necessary for the inception of the first Great Exhibition of the Industry of all Nations. The English government had frequently been urged to hold a really national exhibition in London, illustrating the arts and manufactures of Great Britain and Ireland; they displayed the usual sluggish disinclination of official departments to take new responsibilities; and matters so turned out that the first really great exhibition, forced on the government by the power of public opinion, was not only national, but international.

Before we proceed, it may be well to advert to a classification of such exhibitions, illustrating the great diversities observable in their plan and scope. The new Supplement to the "English Cyclopædia" recognizes eight classes, the characteristics of which we will condense as follows:—1st. Agricultural Exhibitions, with or without illustrations of other departments of industry. Three notable examples of these were held,—at Bordeaux in 1865, Chartres in 1867, and Hamburgh in 1869; in which various trades were illustrated, in addition to those connected with agriculture, grazing, dairy husbandry, and the like. 2nd. Exhibitions of Fine Arts, with a few industrial products as a make-weight. These have been numerous, especially in France; and some of them have been instructive to artizans in illustrating the application of art to industry, the presentation of handicraft specimens noticeable for graceful form or artistic colouring. 3rd. Exhibitions of Special Trades. Among many good examples of these are cited the Exhibitions of Wood Carving, in 1860, by the Society of Arts; of Pottery, in 1865, at Hanley in Staffordshire; of Coachmaking and its Appliances at Coachmakers' Hall; of Mill-stone and Flour Dressing Machines, at Dresden; of Hops, Malt, Beer and Ale, at Dijon, in 1866; of Graining, Marbling, and Decorative Painting, at Painter Stainers' Hall, repeated on two or three occasions; of Olive Oil and Oil-pressing Machinery, at Terni in Italy, in 1871; of Writing and Writing Materials, at Paris, in 1872—and so forth. 4th. Exhibitions got up by the inhabitants of particular towns, of any articles on loan which the townsmen may be disposed to lend. These displays have been numerous, but the collections are too miscellaneous, the arrangement too incongruous, to possess any educational value. 5th. Working Men's Exhibitions. These are nearly as miscellaneous as those composing the fourth class, seeing that they comprise, in addition to the veritable work of skilled artizans, curious but valueless knick-knacks, which have been produced by the same or other workers as amateurs. 6th. County or District Exhibitions, differing from those of towns chiefly in embracing a wider area. We have had some of these in England; the French provinces have done the like; but the most interesting have been those in the colonies, especially the colonies of Australia. 7th. International Exhibitions. These are the grandest of the whole, seeing that they aim at bringing together not merely the various industries of the particular kingdom or country in which they are held, but the analogous industries of nearly all other countries. The wonder is, not that such exhibitions have failed to realize fully the expectations intended and entertained, but that they have succeeded so well as they have, in face of the enormous difficulties surrounding them. 8th. Annual Industrial Exhibitions, partly international in their character. These (as we have recently seen) have had a doleful ending, cut off in the fourth year of an existence intended to be for ten years.

The Great Exhibition of 1851.

We shall now, without speaking further of mere classification, be in a position to glance at that great phase in the history of Industrial Exhibitions, which marked the transition from the national to the international, the works of one country to the works of all countries willing to take part in the undertaking.

As observed in a preceding paragraph, the Birmingham Exhibition gave a great impetus to the movement for something on a more comprehensive and instructive scale; but the movement itself began a little earlier. In the spring months of 1849 the Council of the Society of Arts, with Prince Albert as its prime mover, sketched the outline of a Great Exhibition of the Industry of all Nations, and proposed that such a display should be held in 1851. In July the Royal Prince, in the name of the Society, applied to the government for the appointment of a Royal Commission to organize and manage such an exhibition. Great meetings were held at the Mansion House and Willis's Rooms, to interest the public in the scheme. Early in 1850 the Commissioners were appointed, with the Prince at their head; a very large guarantee fund was subscribed; the consent of the Crown was obtained for the holding of the Exhibition in Hyde Park; and plans for the exhibition building were invited. In June Mr. (afterwards Sir Joseph) Paxton conceived his felicitous idea of a building with walls and roof mainly of glass, the world-renowned Crystal Palace. The first column was fixed in September; the building was handed over by the constructors, Messrs. Fox and Henderson, to the Royal Commissioners early the next year; the exhibits from all corners of the earth were brought in; and the Exhibition was publicly opened by the Queen punctually on the day long previously announced, the 1st of May, 1851.

The lapse of twenty-three years has made the Crystal Palace in Hyde Park a matter of history instead of recollection to a large portion of the present inhabitants of England. Those who wish for a few details relating to it may be interested in knowing that the building was 1851 (a happy choice) ft. long by 408 wide, with an additional width of 48 ft. for half that length; that the highest portion was a centre transept 108 ft. high; that the area covered was 19 acres, equal to seven times that of St. Paul's Cathedral; that there were 3,300 iron columns, 3,500

iron girders, and 4,000 tons of iron altogether; that there were 200 miles of sash bars, 20 miles of wooden gutter, 1,000,000 square feet of flooring on the ground and in the galleries; that there were 1,500 vertical glazed sashes, and 17 acres of glass in the roof. Then, in regard to the appropriation of the exhibiting space, 337,261 horizontal square feet were occupied by England and the Colonies, 272,121 by foreign nations. The exhibitors were nearly 15,000, about equally divided between British and foreign. The cost of the structure was £170,000 (for "use and waste," not for absolute ownership); this, with all the other expenses down to the close of the enterprise, made a total outlay of about £300,000. The visitors, from May 1 to Oct. 11, exceeded 6,000,000; on three particular days the numbers were more than 100,000 each. The money paid by them, together with other receipts, amounted to about £500,000, leaving a surplus of £200,000. One of the most singular features connected with the admissions was this; that on the first shilling day, when the Commissioners and the press expected a tremendous rush of visitors, the fear of this rush operated so powerfully as to deter tens of thousands from going; the timid went on the preceding five-shilling day instead, and thus 34,812 visitors on a five-shilling Saturday were succeeded by only 23,402 on the following shilling Monday.

Quitting statistics of this kind, and coming to the more immediate features for which such exhibitions are noticed in this work, it may be well to state that the total industries of all countries were placed in four groups: *Raw Materials*, *Machinery*, *Manufactures*, and *Fine Arts;* that these groups were sub-divided into thirty classes; and that an equal number of juries awarded medals, &c., to the best exhibitors in each class. What with Council Medals, Prize Medals, and Honourable Mentions, the 15,000 exhibitors received more than 5,000 of these testimonials. The result was gratifying to the majority and less meritorious of the recipients; but it lessened the value of the honour to the really great firms. An example was set which has worked injuriously in later exhibitions; manufacturers and tradesmen, eager to obtain medals for advertising purposes, have valued the international exhibitions on that ground alone, and have been tardy in encouraging those in which this stimulus was wanting.

Various International Exhibitions, 1853 to 1857.

The spur given by the Hyde Park display did not cease to be active. Other towns, wishing to enjoy a pleasure such as London had enjoyed, longed for similar exhibitions; while tradesmen and manufacturers, delighted with their prize medals, wished to obtain more of the same kind. Messrs. Fox and Henderson, constructors of the Crystal Palace, sold the materials to a joint-stock company, who erected the much more splendid building known by the same name at Sydenham—a building the fortunes of which do not come in for consideration here. A really important and creditable enterprise was carried into effect in 1853—that of the Dublin Exhibition of Art and Industry. But for the liberality of one man, Mr. Dargan, it is doubtful whether this could have been achieved at all. Mr. Dargan proposed that the Dublin Society should undertake the work, and that public subscriptions should be invited to set it afloat. He himself gave £20,000 to pay for the construction of an exhibition building, and afterwards increased his liability to £40,000. What his total loss was eventually has not been publicly stated; but the receipts fell greatly short of the expenditure. The Exhibition was slightly international: that is, it comprised specimens of art and manufactures from a few foreign countries; but it was mainly illustrative of home industry. Especially (as was right and proper) was Ireland well represented; never before had there been such a collection of the produce, manufactures, and art of that country. Both in mechanical and in artistic merit Ireland was found wanting; but the manifestation of this deficiency was in itself a good thing, by pointing to the direction in which improvement should be sought.

Of the New York International Exhibition in 1853 we have little to say here, except that it was badly managed, and that it resulted in a loss heavier even than that of Dublin; but the loss was diffused among the shareholders of a company, and did not fall severely on any one person. Nor does it come within our present scope to speak in detail of the Paris Exhibition of 1855. It will suffice to say that the enterprise was carried out by the French Government; that the exhibition building itself belonged to a joint-stock company, between whom and the Government complicated agreements were made; that paintings and engravings were admitted, which had not been the case at Hyde Park in 1851; that there were about 20,000 exhibitors, nearly half of whom were foreign; that 4,500,000 persons visited the Exhibition; that the result was a heavy financial loss to the Government: but that Paris reaped a fully equivalent harvest from the provincial and foreign visitors. Other foreign enterprises were a New Brunswick Exhibition of colonial articles, a Madras Exhibition of native articles, a Munich Exhibition of German articles, and an Edinburgh Exhibition of Scottish Art,—all at various dates between 1853 and 1855.

One exhibition of a remarkable character deserves a little special notice—the Manchester Art Treasures Exhibition of 1857; fine and ornamental art only, not industrial. It was one of the grandest collections of the kind ever brought together. The articles were not exhibited by producers or dealers, but by private owners; and many of them were of a recherché kind, modern and ancient English pictures, modern and ancient foreign pictures, sculptures, water-colour drawings, engravings, etchings, wood engravings, lithographs—all in great profusion. The feature which gave that Exhibition a claim to notice here is, not Fine Art *per se*, but ornamental art as applied to what we usually designate manufactures. In this it eclipsed perhaps all other exhibitions, before or since. The Meyrick and other collections of ancient armour; artistic metal work in iron, steel, brass, and bronze; mediæval goldsmiths' work; weapons and shields of various ages and countries; Majolica and choice pottery; Sèvres and Dresden porcelain; Venetian and other specimens of choice glass; carvings in ivory and wood; ornaments and figures in terra-cotta—these formed an assemblage which illustrated in a way almost unequalled the application of artistic grace to the products of manufactures—the marriage of Art to Industry. Upwards of a million and a quarter persons visited this Exhibition. Viewed financially, the enterprise just about paid for itself, rather a rare thing in these matters.

Estimate of Advantages derived.

Before we come to 1862, the year of our second Great International Exhibition in London (an undertaking not destined to be marked by such brilliant success as the first), it may be well to offer a few incidental remarks.

After 1851, it was natural and proper that an endeavour should be made to estimate the kind and amount of good which the Hyde Park display had rendered; and the later undertaking in 1862 cannot be well understood without some reference to such an estimate. Viewed in its general and social aspects, the first Exhibition was considered to have done good by bringing together thinking men of all nations, and effecting something towards valuable reforms in postal intercommunication, in the laws of patents and copyrights, in quarantine laws, in sanitary economy, in international commercial laws, in the passport system, and in the endeavour to establish a little uniformity (be it ever so little) in the coins, weights, measures, and scientific numeration of the principal European countries. In regard to more technical and industrial matters, the results of the Exhibition were treated in a series of twenty-four lectures, organized by and delivered before the Society of Arts, by such competent men as De la Beche, Owen, Whewell, Playfair, Lindley, Glaisher, Royle, Ansted, &c. It was an object with the lecturers to point out in what departments, as manifested by the exhibits, foreigners excelled ourselves; as a means of determining the nature of the improvements required. India, for instance, excited general surprise by the extent in which she combined artistic forms and colours in her manufactures; the United States took the lead of us in india-rubber manufactures, cheap neat clocks, and various manufactures in plain wood; Austria showed great excellence in furniture and cabinet work; Switzerland and South Germany carried off the palm for toys, and so on. Our working men were afforded an opportunity of profiting by many things which they saw in the palace of glass. As one of the lecturers expressed it, "for the first time had been placed within their grasp a knowledge of what has been done, and is doing, and by whom—a knowledge necessary for the prevention of the useless repetitions which have so often engaged the attention of the ingenious mechanic, who, ignorant that he is doing that which had long been successfully performed, sustains a real injury; while the talent and industry possessed by him are totally lost to other causes which, with better information, he might have successfully embraced." The French are not very prone to admit any superiority in other nations; but one of their critics, M. Lemoinne, struck the right key when he said, "One of the great results will be that all nations will improve by means of mutual example and comparison. If the English give us lessons in industry, they may on their part learn to assign to art, properly speaking, a higher position. Taste is perfected as the level of equality ascends; inferior products are no longer in demand, superfluities have become necessaries, and the beautiful is as requisite as the good."

When several years had passed, and the Paris Exhibition of 1855 had shown an advance upon that of 1851, many large-minded and enlightened men thought a renewed attempt in this country desirable. The Manchester display of 1857 was not a

case in point, for the materials and processes of manufactures, the ordinary industries of everyday life, were not included within the scope of the subjects illustrated. A new Exhibition of the Industry of All Nations was needed.

The Commissioners of the '51 Exhibition, having a surplus of something like £200,000 in hand, laid out the greater part of it in the purchase of the Gore estate at Kensington, in order to appropriate land for the erection of national buildings devoted to art, science, and industry. The Government were to work with the Commissioners. Nothing definite was, however, done for several years, except something at the South Kensington Museum; making the new roads now known as Exhibition Road, Cromwell Road, and Prince Albert Road; enclosing a fine open quadrangle of 56 acres; and letting a portion of it to the Horticultural Society. Meanwhile the Society of Arts, after much discussion, passed a resolution in 1858 to the effect that it would be desirable to hold decennial Industrial Exhibitions in London; and that as the first had taken place in 1851, the second might suitably be fixed for 1861. The majority of the council urged that great changes had presented themselves in many branches of manufacture since 1851; that several firms almost unknown at that date, had since greatly extended and improved their operations; that new phases of mechanical invention, artistic development, and scientific discovery in its application to industrial art, had appeared; and that an interval of ten years would suffice to give a renewed relish on the part of the public for such an Exhibition. Circulars were sent to great manufacturing firms at home and abroad, asking for opinions and suggestions.

In 1859 it became necessary to decide in what building such an Exhibition should be held, if held at all. The Hyde Park Crystal Palace was gone, the Sydenham Crystal Palace was too far distant, and there was no other existing building at all suitable. Unfortunately, just at this juncture, war broke out between France and Italy on the one side, against Austria on the other; and the Society of Arts postponed its scheme, feeling that battlefields would render an International Exhibition well-nigh impossible. But the war having ended more suddenly than had been expected, the scheme was renewed early in 1860, with the valuable support of the Prince Consort (the new designation for Prince Albert). As a year had been practically lost, the date now proposed was 1862, instead of 1861. A guaranteed fund was proposed; and so enthusiastically was the matter taken up, thas this fund rose eventually to the enormous sum of £450,000. The Bank of England would willingly advance money on such security as this, and thus there would be the means at hand to defray the cost of an Exhibition building. The Commissioners of 1851 lent the use of about twenty acres of their land on the Gore estate. Early in 1861 the trustees of the guarantee fund were appointed, by royal charter, Commissioners for the Exhibition of 1862; and to these Commissioners the Society of Arts handed over all power and responsibility in connection with the enterprise.

One feature was resolved upon, following the precedent of Paris in 1855, and additional to anything attempted in London in 1851, viz., the inclusion of fine arts as well as industry. The Commissioners decided that one large and important section of the Exhibition building should be devoted to a collection of examples embracing the entire range of art; that the owners of such works in every country should be invited to contribute the choicest of their possessions; that living artists, wherever resident, should be encouraged to send the best specimens of their genius and skill; that the art academies of every great city should be invited to lend their aid; and, finally, that the governments of the principal countries should be applied to, to render such authoritative support as governments only can render in most foreign countries. These preliminaries having been settled, the Commissioners decided approximately on the size of the new building, engaged Captain Fowke to make designs and plans (aided by hints and suggestions from various quarters), and let the contract to Messrs. Kelk and Lucas. The building was commenced March 9, 1861, and the Exhibition opened May 1, 1862.

London International Exhibition of 1862.

As it is a doubtful problem whether any exhibition on so grand a scale will be attempted in London for a long series of years to come, we will condense into a summary the chief facts connected with that which is known as the "London International Exhibition of 1862."

First, as to the building. The principal structure was a quadrangle 1,200 ft. by 560 ft., with its main frontage in Cromwell Road; while subsidiary to this were two annexes, east and west of the Horticultural Gardens: the whole occupying about twenty-four acres. The main building was of massive brickwork; but the annexes, and two cupolas of great magnitude, were chiefly of glass, iron, and wood. There was a central nave in the main structure, shorter but loftier than that of the '51 building; while courts and corridors on either side were for the general reception of the articles exhibited. Ranges of galleries on the south front of the main block were set apart for pictures and other objects of fine art; the remaining portion of the buildings being devoted to industry and manufactures. The total area of covered space was nearly 1,300,000 square feet, including corridors, staircases, &c. About 700,000 square feet were ground-floor space, the remainder galleries.

Next, the exhibitors, and the articles exhibited. The vast space was so divided by partitions as to present a great extent of vertical wall surface, available for displaying the glittering objects of art and manufactures; insomuch that the space (including passages and avenues) placed at the disposal of the exhibitors amounted to 1,032,352 square feet of horizontal flooring, and 284,670 square feet of vertical wall. About one-half was appropriated to the United Kingdom and its Colonies, the other half to foreign countries. (Unfortunately, the terrible civil war in the United States almost totally prevented that country from exhibiting). In the Fine Arts Department no less than 75,000 square feet of vertical wall space was devoted to paintings, oil and water-colour. The total number of exhibitors was 28,653, of whom 26,348 were in one or other of thirty-six industrial classes, the remainder in one or other of four fine arts classes. How amply sufficient was the supply of fine arts specimens, to occupy not only hours but days of the time of visitors, will be evident from the fact that there were 3,370 paintings in oil and water colours, 1,275 etchings and engravings, 983 architectural drawings, &c., and 901 pieces of sculpture. During the early months of the Exhibition, 620 jurors were busily at work examining the articles displayed, and estimating their relative merits. A troublesome question was that of deciding on the kind of rewards to be given for excellence. In '51 there had been two grades of medals, besides honourable mention; it was now determined to have only one kind, to denote good materials or good workmanship, and not rivalry or grades of merit between competitive exhibitors. The struggle for the *emulative* medals had been so great in 1851, and again at Paris in 1855, and had led to so many unpleasant wranglings between exhibitors, jurors, and commissioners, that one single kind of medal, liberally and even lavishly awarded, was the rule in 1862. This, however, gave dissatisfaction to the leading firms, as placing them on no higher a pinnacle than small and little-known manufacturers. Manage it how we may, the prize-medal system is a thankless one to have to deal with. The juries awarded 8,141 medals and 5,202 certificates of honourable mention; so that nearly one-half of the exhibitors were flattered in some form or other. All the medals were in the department of industry, none in that of fine arts—an arrangement for which artists were not very grateful.

Next, the visitors. The Exhibition of 1862 was open 171 days, about a month longer than that of 1851. There were two classes of season tickets, at five guineas and three guineas, besides half-season tickets at much reduced terms; while the admission payment at the doors varied from £1 (on two days) down to 1s. (on eighty-eight days). The whole number of season tickets was 27,800. The sum-total of visitors was 6,211,103, about 200,000 more than in 1851; but as there were about thirty days more in the season, the average per day was smaller. The *great* day did not compare well with that of the first Exhibition—only 67,891 visitors against 109,960. Tuesday was, on the average, the fullest day of the week, as it was also in '51—a fact that runs counter to the belief of Monday being the favourite idle day in London.

Lastly, the receipts and expenditure. The visitors paid £328,858 at the doors, and £79,672 for season tickets; the refreshment contractors paid £29,285, and other contractors abou £12,000—making a total of £448,632. Unlike the experience of 1851, the receipts did not quite cover the expenditure, owing chiefly to the vast cost of the building itself. This cost amounted to £320,000, virtually for six months' use of the structure, seeing that it passed into the hands of the contractors when the Exhibition was over. Then came the other expenses: £45,778 for salaries and wages; £13,359 for roads and approaches; £23,524 for police, fire brigade, and fire insurance; £21,439 for rent, taxes, gas, water, fuel, fittings, printing, stationery, and advertising; and other items making up a total of £459,637. In order not to come upon the guarantors, Messrs. Kelk and Lucas agreed to forego £11,000 of their claim, or to make a gift to that amount, which enabled the Commissioners just to clear themselves, without loss. They declined to undertake, and had no money to pay for, a body of jury reports such as had been so valuable after the Exhibition of 1851; but the Society of Arts accepted this labour, and sold this important work at such a price as would just reimburse the outlay, to such persons as were willing to purchase.

Thus ended the International Exhibition of 1862. Great efforts were made to retain the building, especially the long range of picture galleries, for future displays on a grand scale. But Parliament, who was at that time ill satisfied with the Committees and other bodies at South Kensington, refused to grant the funds necessary for this purpose. The building was therefore razed to the ground, and the materials sold to a joint-stock company, who employed them in constructing the Alexandra Palace at Muswell Hill. The space has been vacant from that day to this, and is only now being filled up with the new Natural History Museum, which will be paid for, and belong to, the nation. So far as concerns a prospective International Exhibition, the House of Commons might possibly have allowed the structure to stand; but a fear intervened that there would be a constant drain of public money at that spot, for various purposes, in such modes as would give the government very little control over the expenditure. The leading spirit of the whole enterprise, moreover, was gone; the Prince Consort had died in the preceding year; there was no one left so fitting as he to take the lead; and the Queen, oppressed with sorrow, no longer cared for public ceremonial and displays. The Commissioners, too, were half wearied; a brilliant success had been denied to them, such as had rewarded their predecessors in 1851; and every one felt that a long period must elapse before the public would again manifest the same interest as before. The Commissioners wound up their affairs, presented their report to the Crown, and ceased to exist as a chartered body. The Commission of 1851 could not similarly end; it was the proprietor of, or trustee for, a large estate at South Kensington, and of some funds likewise, of which it held the title-deeds.

The lessons taught by the Exhibition were, that English manufacturers had made a considerable advance in artistic taste during the eleven years which had elapsed since the former grand display; that new branches of industry, scarcely known in 1851, had sprung into importance; that many foreign nations, especially France, Belgium, and Germany, were treading closely on our heels in departments of metallic and textile manufactures wherein we had been unquestionably supreme; and that the prize-medal system worked quite as much harm as good, by fostering the advertising tricks of trade, irrespective of the real excellence of the articles produced.

Various Exhibitions between 1862 and 1867.

For reasons already stated, those exhibitions only can be noticed at any length here which were held in England, and were at the same time International; but we may fittingly give a rapid glance at many others.

Constantinople made a small attempt in 1863 by an exhibition of the arts and industry of the widely-scattered provinces of the Turkish empire; but it was a poor affair, presenting few attractions save the jewels of the Harem, sent by the Sultan. Bayonne had a Franco-Spanish display in 1864, comprising manufactured articles of the one country, and raw produce of the other. Dublin entered the lists in 1865, with a scheme more ambitious than the one held in 1853; it comprised both arts and manufactures, and was international in its scope. A joint-stock company had been formed, called the "Dublin Exhibition Palace and Winter Garden Company," and it was in a new structure belonging to that company that the exhibition was held. We are told that this was "the most important exhibition ever held in Ireland; the collection of works of art was unusually fine; a separate hall for musical instruments and concerts provided an attractive addition; the eagerness to contribute was such that sevenfold the amount of available space was applied for, although the exhibition area covered five acres. It was opened by the Prince of Wales amid high anticipations of success. There were 770 British exhibitors, and 288 foreign and colonial; the works of art were no less than 2,082 in number; and indeed much raw produce and many kinds of rough goods, suitable to illustrate every-day industry, were excluded to make room for specimens of fine art. The collection of sculpture was one of the best ever seen in the United Kingdom." The result, nevertheless, was such as to damp the ardour for such displays. In the first place the opening was too long delayed; and in the next place an unusually wet autumn lessened the number of strangers who would otherwise have flocked to Dublin. The total number of visitors was 900,000, against 1,150,000 at the former exhibition in 1853. The receipts, after defraying working expenses, did not pay the rental of the new building in which the exhibition was held.

In the year of the Dublin display (1865), an exhibition was held at Cologne, international so far as to combine the products of industry from three countries, Germany, Belgium, and Holland. Oporto also entered the lists with an exhibition, to which a considerable number of English agricultural machines were sent. In 1866 the three Scandinavian countries displayed an interesting collection of produce and manufactures at Stockholm. The Australian colonies in like spirit combined to hold a most creditable exhibition at Melbourne, illustrating the produce and industry of Victoria, New South Wales, Queensland, South Australia, Tasmania, and New Zealand. A novel and valuable exhibition was held at Agra in 1867, to illustrate the produce, arts and manufactures of Rajpootana, Oude, and other provinces in Northern India; the natives evinced so much interest in the display as to induce a belief that an occasional repetition of such undertakings would be beneficial.

A few words must be said concerning a series known as "Working Men's Exhibitions," one of which attempted to be international. It had been urged in 1851 and again in 1862, that at the displays in those years, facilities had not been afforded for awarding due credit to the actual workmen who made the articles exhibited, the names announced being those of employers and dealers. To remedy this, smaller exhibitions were proposed, so managed as to identify artizans with their handiwork, and to admit visitors at a more economical rate than a shilling per head. The first of these was held in 1864, at the dried-up swimming bath known as the Lambeth Baths. The exhibitors were 144 in number, the admission fee was 2*d.* There were some curious specimens of ingenuity shown, and the humble affair paid its humble expenses. This was followed in the autumn of the same year by a North London Working Classes' Industrial Exhibition, at the Agricultural Hall; it was only open three weeks, but in that time it attracted 200,000 visitors, and was fortunate enough to end with a surplus of £800. This success acted as an incentive to the formation of quite a crop of similar schemes in 1865, including a "South London Exhibition" at Lambeth Baths; an "Exhibition of Arts and Manufactures for North-East London," at the Agricultural Hall; a "West London Working Classes' Industrial Exhibition" at the Floral Hall; an "East London Exhibition" at the Beaumont Institution; a "South-Eastern Industrial Exhibition" at Greenwich; an "Industrial Exhibition of the Society for Improving the Condition of the Labouring Classes" at St. Martin's Hall; and an abortive "Anglo-French Exhibition" at the Crystal Palace. Some of these schemes were too ambitious, and failed through fixing the price of admission too high; some were burdened by too high a rental; some got into perplexities about the prize-medal and certificate system; but taken collectively they gave a considerable amount of pleasure to the middle-class and working-class visitors, although it cannot be said that they effected much towards the artistic or technical education of the artizan. In 1866 two more were held in London, the "City of London Working Men's Exhibition" at Guildhall, and the "Metropolitan and Provincial Working Men's Exhibition" at the Agricultural Hall. They were both successful in a financial sense, and in some measure improvements on former displays. Imitations of this "Working Men" element were shown in Industrial Exhibitions in other towns. By this time, however, working men had become absorbed in the political and trades union controversies of the day, and cared little for Industrial Exhibitions. The years 1867 and 1868 passed over without the holding of one in London; the year 1869 witnessed one at the South Lambeth Baths; and 1870, the most ambitious of all, the "Working Men's International Exhibition" at the Agricultural Hall. This latter was an overstraining effort; foreign nations were in doubt how to interpret an International Exhibition with no royal or governmental commission at its head. Only Italy and Denmark sent anything worth notice from abroad, London shopkeepers exhibited rather than London workmen, the admission fee was too high; and the committee of management were obliged to have recourse to cheap evening concerts, as a means of augmenting their receipts.

Paris Exhibition of 1867.

If the purpose of this article were to describe with equal fulness the International Exhibitions of all countries, we should have to devote the maximum of space to that held at Paris in 1867; of which it has been said that it was "the largest, finest, and most costly ever held in any country. In the number of nations contributing, the number of exhibitors, the quantity and value of the works of art and industry collected, the area of space covered, and the assemblage of visitors from various parts of the world, it was alike unparalleled." But we must limit ourselves to jotting down a few facts and figures relating to this wonderful display. The Exhibition building was a vast oval, 1,550 ft. by 1,250, having a series of twelve concentric galleries and corridors running all round it, and a small garden in the centre. Different branches of science and art were illustrated in different galleries; while to each country was appor-

tioned one section of the entire oval. The oval covered 11 acres. The outer circle, much broader and loftier than the others, was roofed with corrugated iron, and lighted with windows at a considerable elevation; it was occupied by machinery of all kinds. The innermost circle of all was appropriated to jewellery and costly articles of taste; while the others, between the innermost and outermost, displayed the various products and materials of industry and art in accordance with a prescribed arrangement. Outside the actual oval itself were small courts for the exhibition of food-substances, and (appropriately enough) restaurants in unprecedented number and completeness. In our Exhibitions of 1851 and 1862, while the countries were well arranged along the building, the various industries were not so well arranged in each country; but at Paris in 1867 the ordering in this respect was systematic; first machinery; then metallic and chemical manufactures; then textile materials and clothing; then household furniture; and so on to jewels and personal ornaments. Provision was made for exhibits relating to general and special education; fine art in all its branches; and an archæological collection fitted to show the rise and progress of industrial art in the various countries. Outside the oval structure and its various annexes, in the open space of the Champ de Mars, were numerous actual examples of the styles of architecture of most countries, from the tents of the Kirghiz Tartars, the Russian Samoyeds, and the Bedouin Arabs, to the cottages of the peasantry, and up to elegant mosques, summer palaces, theatres, &c. Besides these, buildings to illustrate civil and military engineering were erected. The beasts of burden of different nations were also illustrated by living examples. Altogether, with the 11 acres in the oval, the buildings and open spaces occupied more than 100 acres of the Champ de Mars. The articles exhibited were in 10 groups, divided into 96 classes—a much larger number than had been adopted at any former exhibition.

The exhibitors were 50,226 in number; and their exhibits were examined by 570 jurors, who awarded no less than 12,944 medals, diplomas, and certificates of merit. The total expense incurred reached £800,000, of which about one half was paid by visitors and contract holders, the other half by the Imperial Government and the Paris municipality. Paris was greatly enriched by the vast concourse of visitors during seven months, and could well afford her share of the contribution. All the visits of all the visitors amounted to the wonderful number of 10,200,000.

It was strongly felt and candidly admitted, by the more observant of the English visitors to Paris in that year, that England did not come off with flying colours. Our machinists and manufacturers were about as skilful and enterprising as they had been in 1862, but the Germans, French, and Belgians had advanced greatly; insomuch that our former proud pre-eminence appeared to be leaving us. Two causes were assigned for this—the deficiency of technical education among our workmen, and the baneful influence of trades-unionism. As to the former, there can be no question that the scantiness of proper institutions for imparting technical education retards the development of intelligence, inventiveness, and taste among our artizans. We have no such body as the Ecole des Arts et Métiers at Paris, and have no such means of giving a salutary impetus to technical progress.[1] As to trades-unionism, few impartial persons can fail to see that it acts unfavourably upon skilled industry. A feeling of insecurity and uncertainty is produced by this system in the minds of employers, inimical to their due working in harmony with the employed. "No employer," it has been well said, "can foresee what adverse influences he may be subjected to at the hands of a large proportion of the trades-union leaders, whose one idea ever appears to be that capital is the hereditary enemy of labour. This doctrine, more or less disguised, pervades many of their speeches and published addresses; leading their followers to imagine that by perpetually crippling the power and influence of employers, they are promoting the interests of the employed. In many of our trades which have recently lost ground in the Continental markets, the employers have found the natural and healthy development of their business operations seriously retarded by the manner in which the trades-unionists endeavour to enforce trade rules of an unreasonable and foolish character." Trades-unionism fluctuates in intensity from time to time, and the dark tints of this picture are not always true; but there can be little doubt that, when masters are hampered and fettered by their men, the energy of arts and manufactures will be impaired.

Various Exhibitions since 1867.

The years 1868, '69, and '70 were not marked by many important attempts at International Exhibitions. The best was a Maritime Exhibition at Havre, illustrating almost every matter that could in any due sense be called maritime; especially in relation to ships' fittings and furniture, boats and boat fittings, fishing tackle of all kinds, beacons and life-boats, sea and coast lights, life-buoys and other life-saving appliances, seamen's and fishermen's outfits and clothing. Amsterdam made a display, in 1869, of exhibited articles from five or six countries; chiefly illustrating the cheapness of goods intended for the working classes. New South Wales had a capital Inter-Colonial Exhibition at Sydney in 1870, similar to but more extensive than that which was held at Melbourne four years earlier. The London "Working Men's Exhibitions" have already been noticed, down to 1870.

From 1871 to the present time many small displays have been held, partially international in their character, such as an exhibition of Italian industries at Milan in 1871; an international maritime display at Naples in the same year; a Channel Islands Exhibition at Jersey, and two South American Exhibitions in Peru and La Plata, in the same year; a Dublin Exhibition of Irish Art and Industry in 1872 (guaranteed from loss by Sir Arthur Guinness, a well-known name in Dublin); a Scandinavian Exhibition at Copenhagen in the same year; and two others aiming to be comprehensive enough to deserve the name of International, at Lyons and Moscow respectively.

But of all the enterprises since that of Paris in 1867, the greatest was that of Vienna in 1873. An unfortunate affair, truly: so vast was the scale, that the buildings were not even approaching completion on the day of opening; so great were the land distances over which the contributions from foreign countries had to be brought, that many of the articles did not reach Vienna until the Exhibition was half over; so bad was the management that some features of the scheme could not be presented at all; and so enormously did the hotel-keepers of the city raise their charges, that the mere rumours to this effect scared away or kept away visitors from foreign countries. The Exhibition building was of a length altogether unprecedented in such enterprises—not much less than three quarters of a mile; and the whole area covered was vast. Many parts of the scheme were admirable, if they had been duly carried out (which they were not). Cottages and peasant houses, with their internal fittings and arrangements; articles to illustrate the history of prices at different periods; others to illustrate the progress of discovery and invention; specimens to show the relative excellence of machine work and hand work; samples of commodities forming the commerce of the chief ports of the world; contrasted specimens illustrating the progress made in the chief departments of industry since the first Great Exhibition in 1851—all were admirably conceived, but the scheme was too vast; it did not render the amount of good it might have rendered, because too much was attempted, and because the miscalculation of time was so glaring. The Imperial treasury had ample means of proving that the Great Vienna Exhibition of 1873 was a woeful financial loss.[1]

London Annual International Exhibitions, ending in 1874.

As the period was approaching when something like a decennium would elapse since the great London display of 1862 had been held, the Commissioners of '51 passed in review the arguments for and against any renewal of the enterprise. One fact was strongly impressed upon their minds. The experience of all the great International Exhibitions, except that of 1851, had shown that the cost of an exhibition building is a great stumbling-block. If intended for only one year, the recouping of the outlay would be very doubtful; if intended for permanency, there would arise the questions of the mode of raising the capital, of selecting a site belonging to the Commissioners, of determining the size and style of the structure, of maintaining it in constant repair, and of utilizing it in some way during the intervening years of the decennial period. It had in addition been ascertained that manufacturers were less eager than before to incur the cost and trouble of sending contributions to such exhibitions, unless the prize medals were so abundant as to be made valuable as advertisements; or unless sales, in bazaar fashion, were permitted within the building. Moreover there was much reason to doubt whether the public would flock in such millions as in '51 and '62; the novelty had worn off, the Working Men's Exhibitions had tended to lower the standard, and in many ways the power of exhibitions to attract had seriously declined." Hence arose

[1] See on this subject, "Whitworth Industrial Scholarships," "Practical Magazine," vol. iii. p. 321.

[1] The reader will find various matters connected with the Vienna Exhibition noticed in our past pages; viz. vol. i. pp. 118 and 216; vol. iii. Chinese Court, p. 31, and Artizans' Reports, p. 194; together with numerous illustrations of gems of industrial art displayed on that occasion.

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a question, whether a comparatively small building could be constructed, on terms that would not press heavily on the Commissioners, and to be maintained permanently; whether it would be possible or commercially safe to hold annual exhibitions, each devoted to some small number of industries, and each to differ in that respect from the one that preceded; and lastly, whether foreign countries would so far enter into the scheme as to make the displays International or Cosmopolitan?

In 1869 these questions had been so far answered in the affirmative as to lead to the settlement of a plan for a series of annual International Exhibitions of Art and Industry, to be held in a building constructed for the purpose, permanent in its character. Two strips of land, east and west of the Horticultural Gardens, belong to the Commissioners of '51; portions of these were set apart for two permanent brick structures, each consisting of an upper and a lower gallery, and divided into compartments by semi-partitions and wide doorways. The remainder of the east and west spaces was set apart for annexes, temporary wooden exhibition rooms, and open-air enclosures for heavy machinery and engineering appliances. The plan so far would have completely separated the two sections; neither of which could be approached from the other. To remedy this defect, arrangements of a strange and complicated kind were made with five other bodies—the Committee of Council, the Board of Works and Public Buildings, the Trustees of Albert Hall, the authorities of South Kensington Museum, and the Horticultural Society. In virtue of these arrangements, visitors to the Exhibition would be able to make the entire circuit exterior to the Horticultural Gardens, and to go into the Gardens by extra payment. Two quadrants of corridors gave access from the east and west buildings to the south end of Albert Hall; and some portions of the Hall itself were appropriated to exhibition purposes; while the east and west buildings were connected at their southern end to a range of rooms bounding the Horticultural Gardens on the south—rooms which were the only remaining relic of the Exhibition of 1862. In these rooms some of the curiosities belonging to the South Kensington Museum were placed, and were left to add to the show. Thus the proprietary arrangement was quite a medley; the topographical distribution was equally a medley; and, from first to last, the public never acquired a clear knowledge of the whereabouts of anything they wished to see. Even to find the way to the dining and luncheon rooms was a "pursuit of knowledge under difficulties." There was no grand vista, no point from which a comprehensive view of the interior could be obtained; and this fact was not without its influence in lessening the pleasure felt by visitors.

When it was determined that each year should illustrate some few branches only of art and industry, a scheme was drawn up for the annual grouping—approximately though not necessarily definite. Every year was to embrace the various branches of fine art; specimens of industry exhibited for their tasteful or artistic forms; and examples illustrating the progress of scientific discovery and mechanical invention. The exhibits to vary from year to year were set forth in groups as follow:—

1871. Pottery and porcelain, woollens and worsteds, educational works and appliances.

1872. Cotton trees and wool, cotton goods and machinery, jewellery and gold trinkets, musical instruments, paper and stationery, printing and the allied processes.

1873. Silk and velvet materials and manufactures, steel and cutlery, carriages and other wheel vehicles, substances used as food, the implements and appliances for cookery.

1874. Machine-made and hand-made lace, leather and saddlery, bookbinding, ranges and ovens, building and engineering appliances, foreign and colonial wines.

1875. Printed and dyed tissues and yarns, clock and watch manufactures, brass and copper manufactures, pumps and hydraulic machines.

1876. Gold and silversmith's work, electro-metallurgy and silver plating, skin and fur manufactures, hair and feather manufactures, philosophical instruments, electrical appliances, agricultural implements.

1877. Furniture and upholstery, paper-hangings and house decorations, ventilating and sanitary appliances.

1878. Tapestry and fancy needlework, stained and window glass, plate and cut glass, naval architecture, military engineering.

1879. Straw plait and matting, flax and hemp manufactures, manufactures in tin and lead, pewter and various alloys, dressing and travelling cases, horticultural appliances, useful applications of magnetism.

1880. Chemical and pharmaceutical substances, made-up clothing, locomotive engines, railway plant.

From first to last the public manifested no enthusiasm for these exhibitions. The visitors in 1871 averaged about 8,000 per day; they fell off, in 1872, to something between 4,000 and 5,000, and in 1873 to less than 3,000; while in 1874 they have barely exceeded 2,000. Working men and their families were markedly few in number; and most ladies cared about the place only when "pretty" things were to be seen, or Albert Hall music to be heard. The war between France and Germany damped the activity of foreign contributors in 1871; while dissatisfaction with some of the proceedings led to unpleasant wrangles in later years—English exhibitors of fancy goods objecting to the French being allowed to sell as at a bazaar: the French not caring to exhibit unless they *were* allowed to sell; and the Commissioners puzzled how to decide between them. Then, again, although men of science and manufacturers could purchase reports of the several classes or groups of 1871, written by competent persons and fitted for permanent keeping, nothing of the kind has been attempted since, except short papers in the "Society of Arts Journal," and such articles as the public journals chose to insert. This abandonment of official reports is a great defect in the eyes of foreigners, who wish to see what Royal Commissioners have to say about the results of enterprises founded under high auspices.

The most inglorious ending of any Industrial, especially any International, Exhibition was that which was witnessed on the 31st of October last. Not an atom of ceremony, not a word of leave-taking or explanation. The ten years had been lopped off to four; the series ended before it was half completed; and the season-ticket holders, augmented by penny visitors, (the fee at the doors had been gradually lessened from one shilling to one penny,) took their departure for the last time, without recognition or farewell. If we ask, where were the Commissioners? echo answers, "where?" And yet there are forty-seven of them—six royal princes, two prime ministers (past and present), dukes and marquises, earls and viscounts, baronets and right honourables, professors of art and professors of science, captains of regiments and captains of industry. We know, on lyrical authority, how powerless were "all the king's horses and all the king's men" to deal with Humpty Dumpty; and it would appear as if all the Queen's Commissioners could not make these annual exhibitions pay, nor interest the public sufficiently in them. A School of Cookery and a School of Art-needlework have made a small beginning at all events from the Exhibition; let us hope they will grow up to something useful, to give a little brightness to the dull episode of 1871-2-3-4.

Whatever may take place in foreign countries, it does not seem probable that any attempt will be made, for a long series of years to come, to hold in London a really great and grand Exhibition of Art and Industry of All Nations. We shall require almost a new generation, to give the necessary spur and impetus.

A SELF-PROPELLING TRAM-CAR.

WE are indebted to "Iron" for the following description of M. Leveaux's invention for propelling tram-cars. Its principle consists simply in the application of coiled springs wound up by machinery, and acting in uncoiling, through suitable intermediate gearing, upon the running wheels of the tramway car. Although up to quite a recent date the conception of springs applied to the generation of power has been limited to watches and clocks, mechanical toys, &c., and has been developed on no scale practically larger, so far as we know, than in the well-known self-coiling shutters; yet this is clearly only a question of power and degree, affecting simply the conditions and capabilities of the manufacture, which have indeed, in effect, presented the only difficulties to be overcome.

In application to the ordinary form of tramway-carriage, a portion of the space below the floor of the car is utilized for an arrangement of a series of drums or barrels, containing the springs, which may be arranged transversely in two groups or sets, suitably inter-connected, so as to form one continuous volute, acting to generate revolution of the driving-wheels, and thus effect propulsion of the car. At the terminal, or other intermediate stopping stations, the means of winding up and recoiling the springs, by any suitable fixed steam-engine or other prime-motor, are to be provided, rotary motion being communicated by shafts under the roadway to vertical spindles and geared wheels, which being thrown into temporary connection, for the purpose, with the spring-barrels, will coil the springs until the requisite tension-power is obtained. The means of effecting this temporary connection of the prime-motor with the carriage-mechanism may obviously be varied, without affecting the principle of thus providing stored-up power, self-contained, whereby the cars may be automatically propelled. Adequate brake-power is also provided, so as not only to control and

FIG. I.

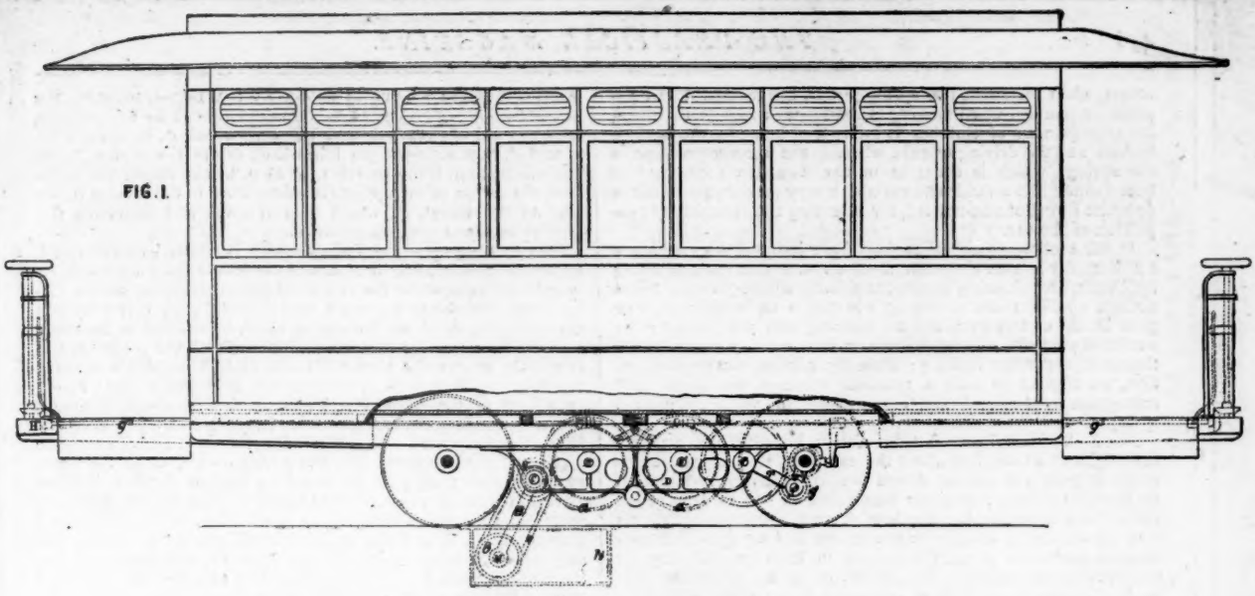


FIG 2

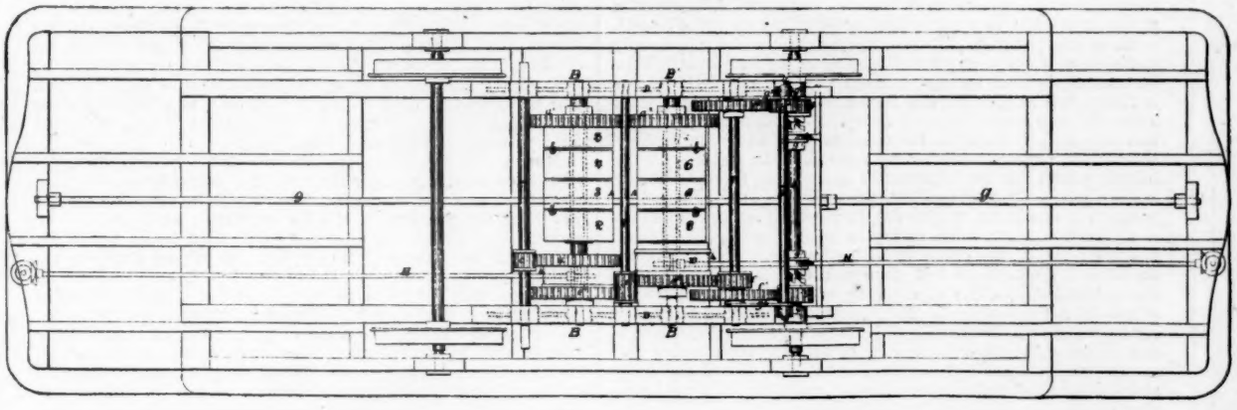
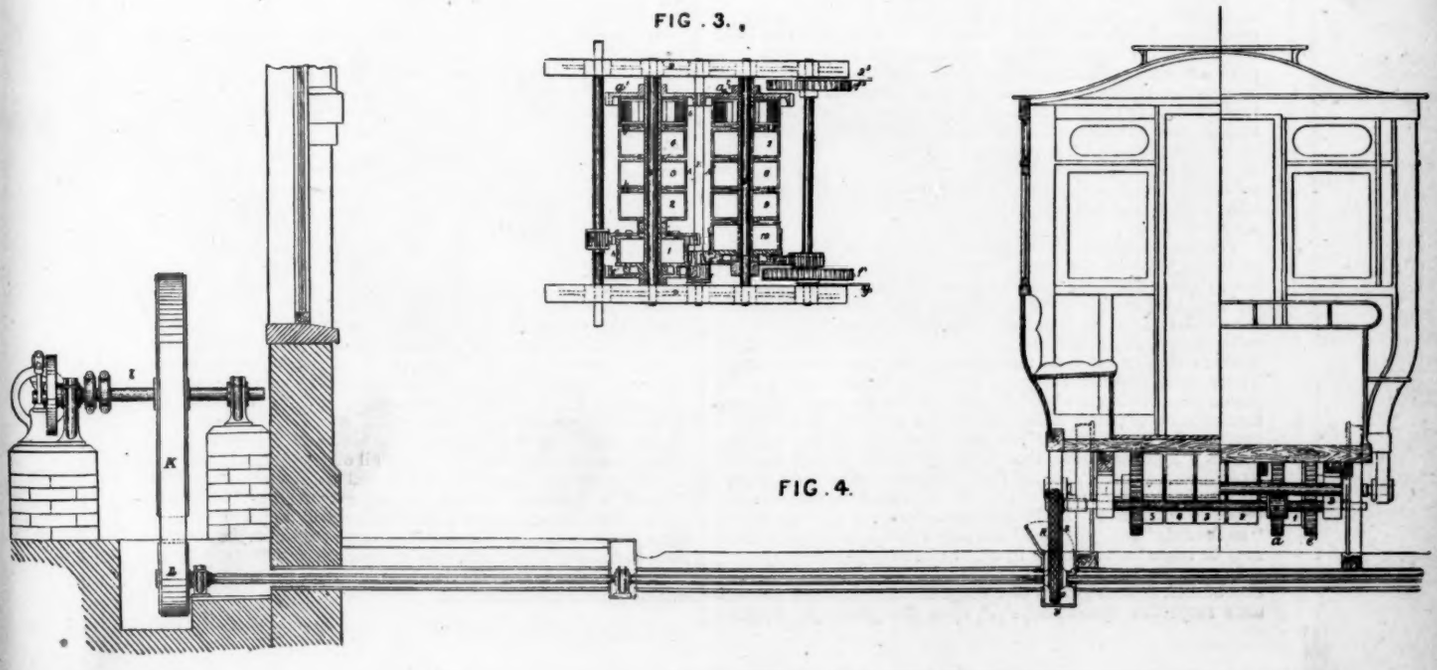


FIG . 3.

FIG . 4.



XUM

arrest, when requisite, the spring-power, but to hold it in complete suspension when the car is stationary: and furthermore, an arrangement of clutches is interposed between the spring-barrels and the driving-wheels, whereby the uncoiling motion of the springs, which is constant in one direction only, may be transformed into an ultimate variable rotary motion, given out in opposite directions as needed, for reversing the direction of propulsion of the car.

In the accompanying engravings fig. 1 represents an ordinary tramway car in side elevation, fitted up with this self-propelling appliance, and showing the mechanism for winding up the coiled springs applied thereto. In fig. 2 is shown an inverted view or plan of the underside of the car-framing and mechanism; the sectional plan of the spring-barrels or drums and gear connected therewith appearing in fig. 3; while fig. 4 demonstrates in elevation, as applied to such a tramway carriage, the mechanical arrangement proposed for employment in winding up the springs.

Fixed horizontally and transversely beneath the carriage flooring, and situated at about the centre of its length, are two series or groups of hollow drums or spring barrels, A, A^1, fitted on to sleeve-shafts, carried on fixed axles, B, B^1; in each group there are five barrels, but any less or greater number of barrels may be employed, as may be convenient and requisite. Simultaneous operation of all the springs in both groups may be secured and maintained; or, on the other hand, action may be limited to the springs of one series only; the arrangement and details being as follows.

A winding-shaft, C, is fixed in bearings in the cheeks or side-plates, D, fitted to the underside of the carriage-framing, which carry also the drum-axles, B, B^1. On the shaft, C, is keyed a pinion, *c*, geared into a spur-wheel, *a*, affixed to the spring-barrel, 1, the first of group A. The spring-barrels, 1 and 2, are loosely mounted on a sleeve on shaft B, and severally connected thereto by means of coiled springs, whereof the coil for the barrel 2 is in the reverse direction to that for the barrel 1; the barrels 3 and 4 are similarly carried by, and reversely connected to, another and independent sleeve on the same axle. Connection between the barrels 2 and 3 is effected by a pin, *b*, at the periphery of the barrels, which thus acts alternately as a driver, to transmit the coiling power from the prime-motor, passing through spring-barrel 1, or *vice versa*, to give out the power of tension stored up in the coiled springs, when acting in their turn as prime-motor. A similar pin, *b*, also connects spring-barrels 4 and 5, whereof the latter is mounted on and connected with a separate sleeve, and carries a spur-wheel, a^1, engaging in another like spur-wheel, a^2, affixed to the spring-barrel, 6, the first of the second group or series, A^1, carried on the axle, B^1; the arrangement and connection of the spring-barrels, 6, 7, 8, 9, and 10, constituting the second group, are precisely similar; and the last barrel, 10, of the series is provided with a spur-wheel, e^3, engaging into the intermediate gearing actuating the driving-wheels.

Centrally located between B and B^1 is a supplementary axle, E, also carried in the side-plates, D, and serving to carry a loose pinion, *e*, engaging in the spur-wheels, e^1, e^2, which are respectively mounted on shafts, B and B^1, so as to run loose; the wheel, e^1, is connected with the spring-barrel 1, by means of a pawl and ratchet, just as in the case of e^3 and 10. Friction-brakes, *h*, thrown in and out of action by brake-rods, H, H^1, extending forwards and backwards to the opposite ends of the car, and by lever handles, and operated by bevel-gearing, as shown in fig. 2, are fitted on the peripheries of the spring-barrels 1 and 10, so as to act as detents for the prevention of the running down or uncoiling of the springs of both groups, when in action; or otherwise, when released, to permit them to exercise their tension-power.

The counter-shaft, F, carried in bearings in side-plates, D, serves to transmit the spring-power and rotary motion to the axle, G, of the driving wheels, by the medium of spur-gearing, f, f^1, f^2. Upon this driving axle are two pinions, *g*, loosely mounted, and having clutch-teeth on their bosses, formed to receive respectively the teeth of a pair of clutches, g^1, sliding on feathers on the shaft, G, and actuated by the clutch-rods, g^2. These constitute the reversing gear; for forward motion, the pinion into which the wheel, f^1, gears, is thrown into action, the transmission of power being direct; for reversal to backward motion, the spur-wheel, f^2, is put in action, driving an idle pinion, g^3, gearing into the adjacent pinion, *g*, and running loosely on a shaft, g^4, having its bearings in radius rods, g^5, respectively pendent from shafts, P, G, and thus transmitting opposite rotation to G. It will be understood that the terms "backwards" and "forward" are only relative, and that motion may be imparted to the car in either direction indifferently.

In case the barrels, 1 and 10, are both released from the friction-brakes, *h*, both groups of springs exert their power through their respective spur-wheel, e^1, e^3, upon the pinion, *f*. If, however, the brake be put in action on the barrel, 10, only, the tension-power of group, A^1, is transmitted back by spur-wheels, a^3, a^1, in aid of group, A, and the spur-wheel, e^1, by the pinion, *e*, and e^2, now acting as an idle-wheel, drives the pinion, *f*; on the other hand, if the barrel, 1, be held by the brake, and 10 be free, the action of the springs is transmitted in the reverse direction to the wheel, e^3, which thus receives and transmits the whole combined propelling power.

The winding-up of the spring-barrels is effected, as explained, by engine power, located at suitable intervals along the track, as may be convenient for the run, or at special stopping places. In fig. 4 the stationary engine, I, and fly-wheel, K, drives by belt the pulley, L, fixed on horizontal shaft, M, carried in bearings, enclosed in a metallic tube or casing, beneath the roadway, and extending across the tramway track, close alongside whereof a covered box, N, is sunk in the roadway, enclosing a chain-wheel, O, affixed on the shaft, N. The endless pitch-chain, P, passes round O, and a second chain-wheel, Q, carried on a pair of radius arms, R, supported on M. The axle of Q is fitted with a sleeve so shaped as to connect with the winding-axle, C, of the tramway car, and thus give the requisite motion thereto. On the arrival of a car at any station requiring to have its spring-tension renewed, the chain-wheel, Q, is raised into position, connected with the shaft, C, and the spring-barrels are wound up by the engine, which being done, Q is disconnected, and depressed into its original position. A friction-coupling or other like appliance may be introduced at any suitable and convenient part of the apparatus, to prevent overwinding.

The crucial point of the whole system clearly relates to the size and power of the springs; the arrangement adopted, of connecting together the springs alternately by their arbours and peripheries, practically unites all the separate springs of the two groups into one continuous coil, exerting the power of each individual member of the series (supposed of equal strength), but exerting that power through a proportionately longer period. The power and duration of the springs must be adequate for the maintenance of the requisite maximum (though limited) speed for a period or journey of sufficient length.

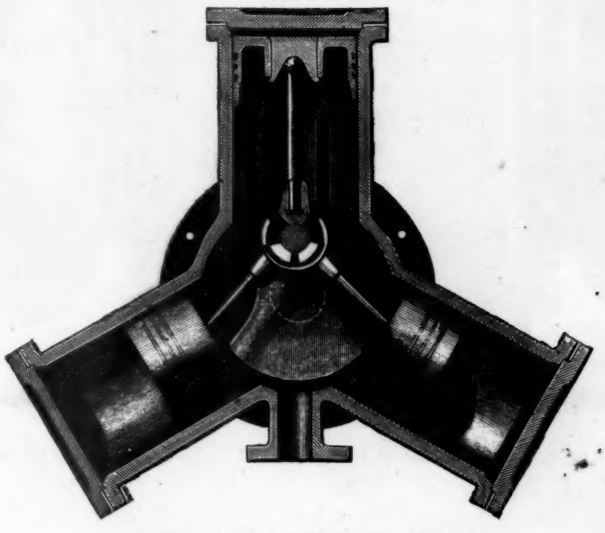
Now it has been computed that the actual tractive force, requisite to overcome the resistance of a tramway car weighing gross 5 tons, is 60 lb. on the driving wheels, corresponding to 720 lb. on the periphery of the spring barrel; 24 lb. and 288 lb respectively correspond to a gross weight of 2 tons; and in like proportion for intermediate weights. So far as previous experience goes, a spring 6 lb. in weight, exerting a direct pressure of 105 lb., may be taken to represent the maximum in size and power of such steel springs. Under the stimulus applied by M. Leveaux's researches, the steel manufacturers of Sheffield, by special and improved plant, annealing ovens and appliances, have turned out springs 50 to 60 feet long, capable when duly coiled of exerting a pressure of 800 lb. to 900 lb. without permanent set; in France also, steel driving bands, with great elasticity, are made 100 yards in length, so that the question of the possibility of obtaining springs of the requisite size and power is practically solved.

Having satisfactorily tested the principle in a working model, to one-sixth scale, on a small temporary tramway of considerable length, M. Leveaux has had all the necessary mechanism and appliances made by a well-known firm of engineers, so as to fit up a tramway car, or cars, for actual travel upon some of the lines of metropolitan tramways in London; for which, indeed, the arrangements are now nearly complete, so that the practical working of the system will speedily receive a thorough public demonstration. The Edinburgh Tramways Company have also, as we learn, entered into an arrangement for satisfactorily proving the power and utility of the system; and the invention is calculated to attract careful and attentive consideration in all quarters, both at home and abroad. We have ourselves had opportunities of seeing the potentialities of the principle, both in the model and in full working size; and even in view of the sweeping change in the tramway system which is involved in its complete success and adoption, we cannot withhold the conviction that all the important practical difficulties have been effectually surmounted, reducing its practical realization to mere matters of detail. The working of the springs is entirely free from noise, perfectly smooth, easy, and effective, and completely under control, for application, cessation, and reversal. As an automatic motive power, free from all objection from other and contemporaneous kinds of traffic, and calculated to supersede entirely the necessity for the employment of horses, with all its concomitant cruelty and inconveniences, it appears to us to open up an encouraging and satisfactory prospect to the directors and shareholders of tramway companies, and to supply the means for the fullest development of intercommunication in urban and suburban districts.

PATENT THREE-CYLINDER ENGINE AND HELICAL PUMP.

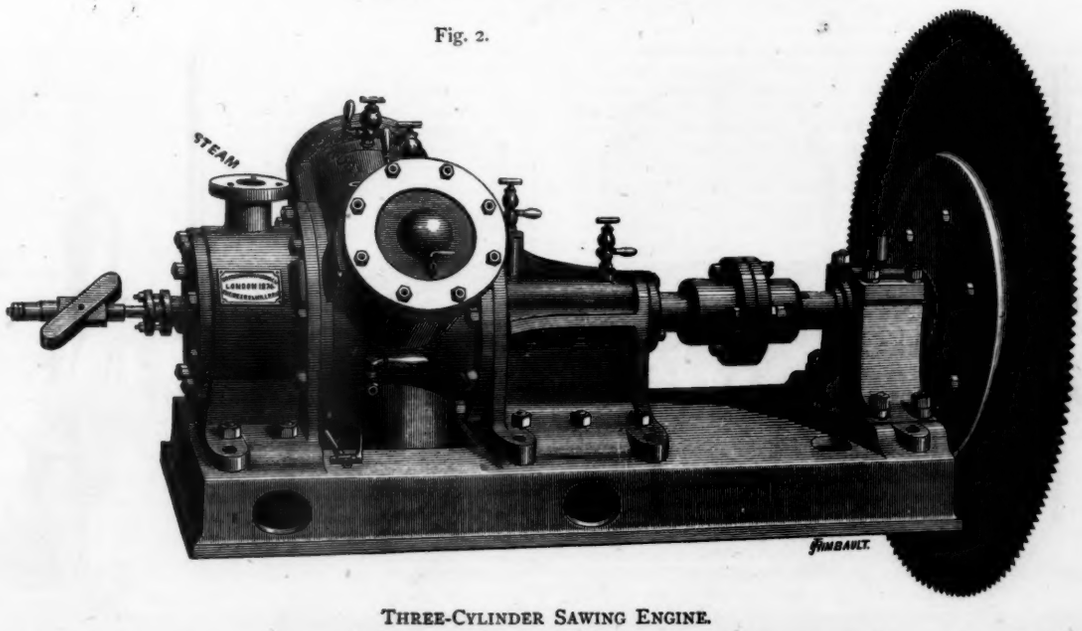
THE illustrations annexed show two mechanical contrivances alike remarkable for simplicity and compactness; they are respectively a steam engine, called the three-cylinder engine, and a rotatory pump called the helical. Fig. 1 shows the engine in section, and will be seen to consist of three cylinders set at angles of 120° to each other, each is what is known to engineers as a single acting engine or cylinder, inasmuch as the steam acts on but one side of the piston. The steam supply to each is regulated by a rotatory valve at the centre, in line with the crank shaft which actuates it, the connecting rods are only in compression, consequently they are merely fixed in and abut against a recess in the piston, which is lined with a suitable bearing metal, while the other end is connected properly to the crank as shown in the section fig. 1. From this method of working and the steam strain being always in the one direction, obviously no "hammering" can arise from loose brasses, &c. For engines of moderate power

Fig. 1.



SECTION OF THREE-CYLINDER ENGINE.

Fig. 2.

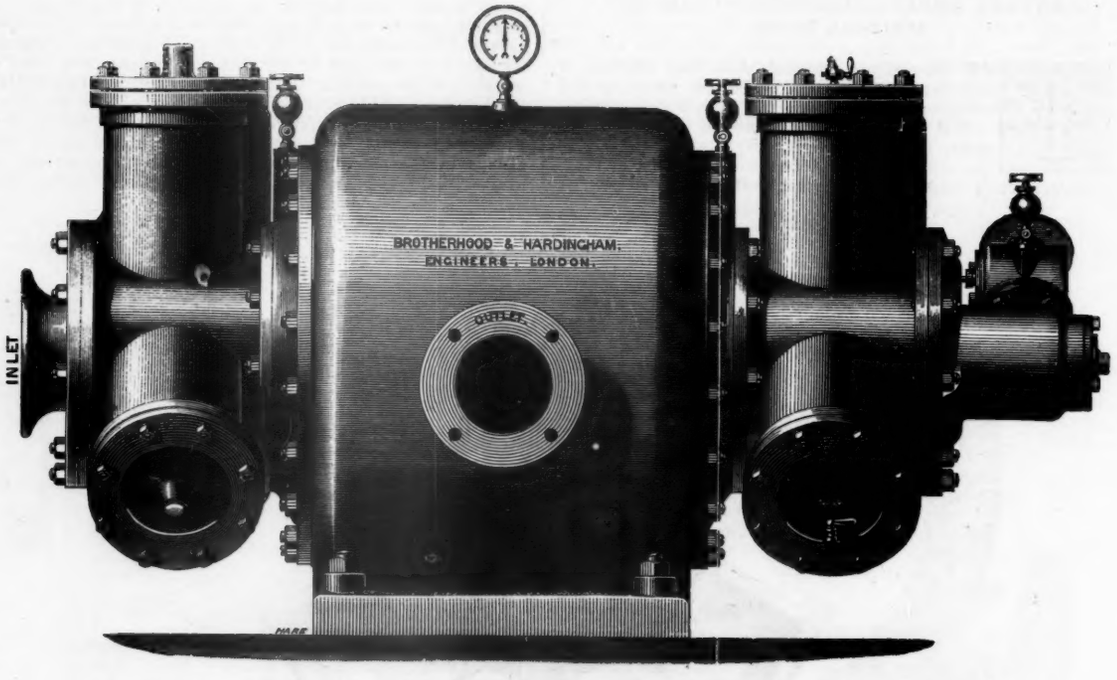


THREE-CYLINDER SAWING ENGINE.

indeed this arrangement appears admirably adapted, and great speeds may be attained with it in safety. Fig. 2 shows the engine as fitted to drive a circular saw for cutting rail ends. Fig. 3 is an air compressor for blowing or ventilating purposes. The air chamber is in the centre, the engine at one side, and a three-cylinder air compressor at the other. The above have all been invented and patented by Mr. Brotherhood, of the firm Brotherhood and Hardingham, engineers, of London.

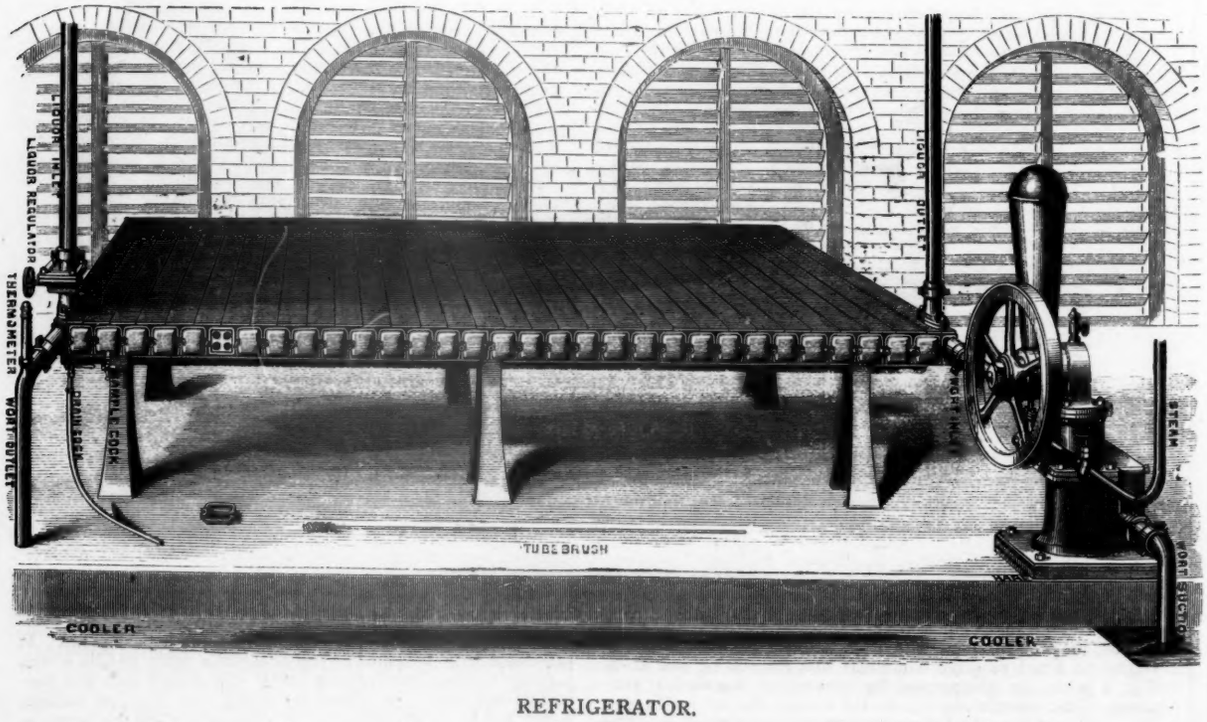
Figs. 4 and 5 illustrate an invention patented in 1868 by Messrs. Boulton and Imray, and also made by Messrs. Brotherhood and Hardingham; it is known as the helical pump. It may be shortly described as consisting of a plain paddle wheel, rotating between two inclined surfaces, provided with two tangential openings, one above for outlet, the other, or suction, being below, as shown in fig. 5. The action of the pump is simple, according as the paddle wheel rotates, the water entering at the one point is gradually shifted to the opposite or higher side by the slant of the inclined casing; the current of water, in fact, much resembling a rope being coiled on to a barrel;

Fig. 3.



THREE-CYLINDER ENGINE AND THREE-CYLINDER AIR COMPRESSOR COMBINED.

Fig. 6.

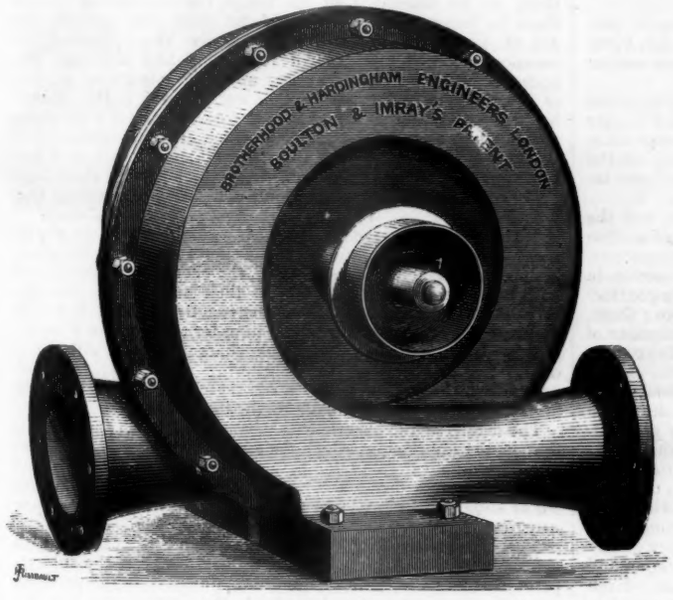


REFRIGERATOR.

according as it is received at the one end it coils screw fashion to the other end, and if the barrel be vertical and the rope paid on to the barrel below, it will of course be given out above. If driven at a certain speed the pump will raise water to a height double that due naturally to its velocity, but the pump works more economically if driven at such a speed as to send the water at a speed equal to its natural head for like velocity. Worked in this way we understand that the pump gives a result of 78 per cent. of the total power expended, in actual effective work done.

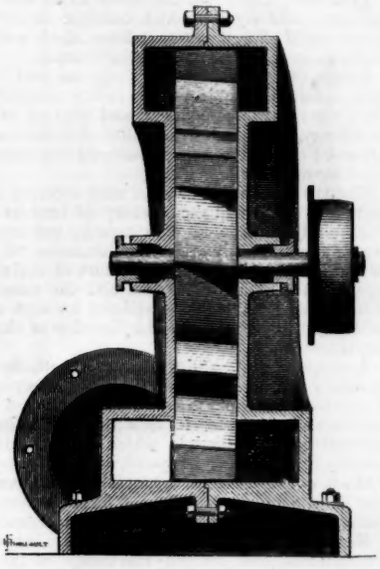
Fig. 6 illustrates a patent refrigerator for brewing purposes, perfected and manufactured by the same firm. It will be seen to consist of a number of long boxes placed side by side, or otherwise if convenient. Each box has a flow and return passage for the liquor, and is provided with copper tubes through which the wort passes. The hollow covers at the ends of the boxes afford com-

Fig. 4.



ELEVATION OF HELICAL PUMP.

Fig. 5.



SECTION OF HELICAL PUMP.

munication for the wort between one tier of tubes and another; each of these boxes is thus a complete refrigerator in itself, and forms a unit of the whole. The advantages claimed for this contrivance are that the formation of sediment is reduced to a minimum, and even this can be removed by taking off the covers and passing a cleaning brush through the tubes. The interior of the tubes can thus be made visible from end to end for inspection. Another advantage claimed is the protection of the wort from the atmosphere while it is cooling, thus preventing loss of the aroma and by evaporation. In places where the fall from the coolers to the fermenting squares is moderate, it is advised that a circulating pump be used to force it through.

Practical Literature.

ANIMAL LOCOMOTION.[1]

THE "International Scientific Series" was originated between three and four years ago, the aim of its projectors being to give authentic, yet popular, expression to the latest advances of thought on the leading subjects of progressive inquiry—including the more important steps of physical investigation, and giving distinctive prominence to those branches of science which help to a better understanding of human nature and the economy of human life.

In perfect harmony with this intention are the two books, forming a part of this truly valuable series, which lie before us. The movements of animals on the land, in the water, and in the air, are phenomena which form so large a portion of our every-day experience that we all of us possess more or less acquaintance with them, and have some knowledge of the principles which govern them. A more perfect knowledge than that which can be gained by mere ordinary observation is, however, of considerable necessity and importance to us, and these two volumes are, we believe, the first popular yet scientific treatises which have appeared on the subject.

In fact, since the publication of the results of the investigations and experiments made by the Italian Borelli nearly 200 years ago, the subject has, until comparatively recent years, received little more attention in the way of true scientific treatment, than a passing allusion or a short chapter in the manuals and treatises on Animal Physiology. During the last few years, however, there has been a growing interest in the subject, especially with reference to its practical outcome in the matter of aëronautics, and the names of both Dr. Pettigrew and Professor Marey are well known as being the foremost in the exposition of the subject as well as in the controversies to which the questions of animal movements have given rise.

Before dealing more particularly with the contents of these volumes we may remark that both our authors agree in believing that artificial flight and aërial locomotion may ultimately become possible to man. Dr. Pettigrew argues, and we must say with a somewhat characteristically unscientific looseness, that man has beaten every other animal on his own ground and that therefore the bird is to be conquered in its own element. This is hardly, as it seems to us, cogent reasoning, and is too much of a piece with many of Dr. Pettigrew's statements and arguments. He intimates that all we have to do is to imitate the movements and mechanism of flying creatures in the construction of machines for aërial locomotion, but our known means of obtaining motive power involve the accumulation of matter which would weight such a machine far too heavily in proportion to the supporting strength and propelling power which it would possess, and it is this element which is constantly throwing out the calculations of inventors of flying and air-navigating machinery.

Dr. Pettigrew also states that it is with a view to simplifying

[1] *Animal Locomotion; or Walking, Swimming, and Flying, with a dissertation on Aëronautics.* By J. Bell Pettigrew, M.D., F.R.S., &c., &c. Illustrated by 130 engravings on wood. London: Henry S. King & Co. 1873.

Animal Mechanism; a Treatise on Terrestrial and Aërial Locomotion. By E. J. Marey, Professor at the College of France, and Member of the Academy of Medicine. With 117 illustrations, drawn and engraved under the direction of the author. London: Henry S. King & Co. 1874.

Being Volumes VII. and XI. of The International Scientific Series.

the conception of flight that his book was mainly written—why, therefore, was not his title-page framed accordingly?—and herein, we think, lies one reason for the wide distance which separates it from the very superior work by Dr. Marey, which, with his, we have placed at the head of this article. Dr. Pettigrew's views—often unscientific and hastily formed—and the theories he is desirous of establishing, are persistently brought forward, evidently with more care for the propagation of the theory, than for arriving at a sound scientific conclusion, and thus, in many parts of his book the special pleader is much more apparent than the calm and dispassionate inquirer into the vast problems which in Nature we find set for us to work out.

Professor Marey, on the other hand, with a clearness, perspicacity, and vigour, which contrast strongly with Dr. Pettigrew's not at all well written volume, deals with the whole subject in the most complete and precise manner.

Forces in the Inorganic Kingdom and among Organized Beings, form the subject of his earlier chapters, in which matter and its action are considered, and the Law of the Conservation of Energy,—the Indestructibility of Force—as bearing on the Animal Frame, are expounded and discussed in the most interesting manner.

The Origin of Animal Heat next receives attention, and the most recently established theory of heat as a mode of motion is carefully considered with especial reference to his subject. Out of this naturally arises the discussion of animal motion in its special aspects, and the structure of the muscle, its contraction, and the nature of its fibre and the muscular wave; these, in turn, lead to the consideration of its work and the manner of its doing it, together with the function of the nerve in connection therewith.

A chapter is then devoted to Electricity in Animals, and Professor Marey establishes an analogy between the discharge of an electrical apparatus and the shock of a muscle; proceeding immediately after to view the mechanism of man as constructed on the principle which governs our construction of machinery, viz. the correspondence of the structure to the work it has to perform. Here, again, the most important and beautiful law of the indestructibility of force is seen. Machines only change the form of work, but do not increase its quality.

Next follow chapters on the harmony between the organ and the function, and on the variability of the skeleton. Each muscle and each osseous structure presents in its form a perfect harmony with the nature of the act which it has to perform. The same muscle and the same set of bones, in different species of animals, present variations of form, if the functions vary which they have to fulfil. For example, in the skeleton the angles formed by the junction of bones are greater in those animals which move quickly than in those whose movements are slow, as, to take an extreme instance, in the case of the elephant. A curious instance of the variation of the organ in accordance with its function is presented by the ostrich, the bones of the joints in the legs, which are used with tremendous effect in running, form almost right angles, while the wing presents no such sharply defined angles in its osseous structure, that organ being comparatively little used. Again, the muscles of the thigh in animals vary according to their mode of motion, and Dr. Marey elucidates this point with great fulness. Evolving from these considerations, the aphorism that *the function makes the organ*, he finds in this a direct confirmation of the theory of development and of Darwinism, and predicts for the old school—which holds the organized world as almost unchangeable—nothing better than ultimate defeat.

From these as it were preliminary considerations, and upon the principles laid down in these chapters of the first book, Professor Marey builds up his treatise, proceeding to deal more especially with the function of the animal both in terrestrial and aërial locomotion in the remaining two books, which form more than two-thirds of the volume.

It is clearly established by our authors that walking, swimming, and flying are all modifications of the same principle. Who it was that first established this principle, more particularly with reference to the flight of the insect, has been a subject of considerable discussion, Dr. Pettigrew asserting that two years after he expounded it at a meeting of the Royal Institution in March, 1867, Professor Marey published a course of lectures in which it was put forward as a new theory, and stating that he wrote a letter to the French Academy, to which Professor Marey replied, admitting entirely, to quote his own words, "la priorité sur moi à M. Pettigrew relativement à la question ainsi restreinte." It is also established that the undulations made by the wings of animals and insects correspond to the waves of the water, as well as of the air, and the various peculiarities of structure adapting the animal to the medium in which it lives and moves and has its being, are set forth at great length and with much minuteness in both volumes.

Experiments with living creatures and with machinery constructed to imitate their movements, have been conducted with immense care and delicacy, in order to determine their peculiarities of motion, and it is curious and interesting to note the many new facts which have been brought to light by the experiments and researches.

In Professor Marey's book the man and the horse are taken as representing the genuses of biped and quadruped, and their movements are carefully analyzed and registered by means of ingenious self-recording and other apparatus made to photograph them as it were in such a manner as to enable them to be studied from the traces the instruments cause them to leave behind. It would be impossible without the aid of illustration to accurately describe these methods of notation of the motion and of registering and analyzing the paces, nor have we space to enter upon the interesting studies of the rhythms of the pace by the ear, of which Dr. Marey has availed himself so largely. But we may extract a passage, which, while showing the spirit in which these inquiries have been prosecuted, will possess an especial interest for those of our readers who remember the discussions which arose a short time since à-propos of Miss Thompson's now-celebrated picture the "Roll-Call."

"The aim of these experiments is twofold, as far as physiology is concerned we derive from the expression of the duration, actions, and re-actions of each pace, the energy and duration of each movement and the rhythm of their succession. But the artist is no less interested in knowing exactly the attitude which corresponds with each movement, in order to represent it faithfully with the various *poses* which characterize it. All these details are furnished by the registering apparatus; the artist need fear no error if he conform his sketches to the indications furnished by the tracings made by the instrument."

The details of the experiments in connection with the *pistes*—that is, the impressions which the feet of the horse leave on the ground—are of extreme value to the artist, and this section of the work gives some invaluable suggestions with reference to the whole subject of animal movements, especially concerning their artistic presentment.

The last book in Professor Marey's volume is occupied with the flight of insects and birds, and this division of the subject, perhaps, has received more minute treatment than the previous one; the apparatus for registering the movements, and for their graphic and optical determination, are still more delicate. The theory of flight which has been propounded by Dr. Pettigrew has recently given rise to some very interesting discussions, but the balance of the opinions of other scientific men who have made the subject their especial study, seems generally to be in favour of Professor Marey's views and conclusions wherever he has established a principle which had differed from those enunciated by Dr. Pettigrew.

We cannot take leave of this subject without again referring to the thoroughly scientific, but clear, incisive, and often brilliant style, in which Professor Marey's work is written: nothing, however, is sacrificed for the mere sake of effect, and his book is altogether one of the most able of the very high-class collection in which it appears. The translation seems to be generally well done, and the English is fluent and easy reading, although it is not quite perfect in some respects. We observe, for instance, that the readings of the thermometer are given in degrees centigrade—sometimes without it being stated which they are, the equivalent in degrees Fahrenheit being in no case given—and we think it would have been an advantage if the weights and measures had been given in their English equivalents, instead of in the French form. But if it were thought needful, all the alterations suggested could easily be made in a future edition.

Both the volumes before us are in every respect excellently produced, and are profusely illustrated, nothing having evidently been spared in the way of engravings which would in any way serve to elucidate the text. All of the engravings in Dr. Pettigrew's book—many of which are of exquisite beauty and finish—were drawn and engraved by Mr. William Ballingall, under the immediate supervision of the author, and the illustrations in Professor Marey's work were produced under his personal superintendence.

PATENT LAW.[1]

IN 1623 an act was passed by King James, entitled "An Act concerning Monopolies and Dispensations with Penal Laws, and the Forfeitures thereof," having for its object to render the Crown incapable of granting any more exclusive privileges, but limiting such grants to a period of fourteen years. Ever since that time the Crown has issued Letters Patent—*litteræ patentes*,—*i.e.* letters not sealed up, but exposed to view, with the Great Seal pendent at the bottom, and several Acts of Parliament referring to this subject have been passed since this 21 Jac. I. c. 3. The one on which the present law is based is the 15 and 16 Victoria, cap. 83, which was passed in 1852, and is called "An Act for Amending the Law for granting Letters Patent for Inventions."

Before the passing of the act of James I., a monopoly might be granted to anyone "who by his own wit or invention did bring any new trade into the realm." The present object of granting patents is that the person who has benefited the public by bringing some new and useful manufacture into the country, may be rewarded for his ingenuity and trouble, and for the expense to which he has been put in perfecting it.

It will be seen, then, that "a patent is not a grant of a monopoly in the sense of the old definition, but is a grant by the crown to an inventor, for the right of practising a new and useful invention for a limited time. The patentee may be looked upon as a purchaser from the public; for an inventor has not an exclusive property in an invention, he has only the right to exercise his own invention freely for a limited period: and the consideration for which this grant is made, is the benefit to the public resulting from the invention of it; first under the patent, and secondly after the term has expired. On the other hand, the patentee is not obliged to make his invention known, he may keep it a secret; it is, therefore, only reasonable that if he makes it known he should receive some compensation from the public who are to have the ultimate benefit of the invention.

"The mode of securing such benefit to the patentee, adopted in this and almost every other country, namely, of granting to him the sole right of using his invention for a limited time, seems to be the best that can be devised. In certain cases where the merit of the invention has been very great, or where the inventor could not be rewarded in any other way, grants of public money have been made, but it is evident that this course could not be adopted in every case, not only from the expenditure of money that would be required, but also from the impossibility of ascertaining what the proper remuneration should be; whereas, by granting a monopoly the gain made by the inventor, when his invention is known, will be proportionate to the amount of benefit which the public will derive from the use of it."

Mr. W. Fischer Agnew has given us in the volume from which we have just quoted, the most modern and complete exposition of the Law and Practice relating to Letters Patent for Inventions, a subject which, from the technicalities involved in it, and the great want of precision in many of the terms of the act, is one of which it is extremely difficult to give anything like a complete presentment. Since the publication of Hindmarch's treatise on the Law Relating to Letters Patent in 1846, there have been scarcely any works published which comprehensively and exhaustively treat this subject. The Messrs. Johnson's "Patentee's Manual," which contains notices of every important case decided in the courts affecting this law, and their "Concise View of the Law connected with Letters Patent for Inventions," which is a very useful exposition of the leading principles and salient points of Patent Law, being, perhaps, almost the only two books in use by the profession at the present time. But since the publication of these books many important cases have been decided, which have to a very large extent modified the views which have been held on certain points of the law, and as it is upon such decisions and upon the interpretations given by the judges, rather than upon the *ipsissima verba* of the act itself, that the majority of the cases which come before the courts are decided, the present volume is one for which a special need existed, and we are glad to see that the want has been so ably supplied. The whole subject is one of such great importance to our readers that we propose briefly to glance at some of the leading features of the law in its present aspect, as expounded by our author, from whose work we shall take occasion to quote somewhat largely in the course of our remarks.

We hope we shall thus give a general view of the questions affecting the Patent Law, which will possess considerable interest and be not without some degree of utility, but we strongly urge all our readers who have to do with inventions and who are using patented processes and patented machinery, to procure a copy of this work without delay; a careful study of it beforehand will save many an inventor who is intending to patent his scheme,—as well as many an owner of patents,—an immense deal of time, trouble and expense.

In speaking of the persons to whom Letters Patent may be granted, our author clearly lays down the rule, that it must be to the "true and first inventor," and that the invention must be that of the patentee himself. If it be not, the crown is deceived, the interests of the public are prejudiced, and the patent is void.

The task of determining who is the "true and first inventor" is often one of great difficulty, and some of the most important of these difficulties which have been encountered and overcome are enumerated in this volume: when two or more persons simultaneously make a discovery, or an invention, the first patentee is held to be the inventor, and is entitled to the full protection. Another important point is established in the following extract:—

"If a servant, while in the employment of his master, invents a machine, the invention belongs to him, and not to the master. But if an inventor employs mechanics to work out the details of his invention and to carry his idea into execution, anything suggested or invented by any person so employed, and subsidiary to such idea, is the invention of the patentee" (p. 7). On this head Chief Justice Sir N. C. Tindal says: "It would be difficult to define how far the suggestions of a workman are to be considered as distinct inventions by him, so as to avoid a patent incorporating them taken out by his employer. Each case must depend upon its own merits. But when we see that the principle, and the object of the invention are complete without it, I think it is too much that a suggestion of a workman employed in the course of the experiments of something calculated more easily to carry into effect the conceptions of the inventor, should render the whole patent void" (p. 8).

With reference to the importation of inventions which are new in England, the importer has been held to be the "true and first inventor," but if a patent is taken out as for an original invention when it is in fact communicated from abroad by a British subject, it is void.

We now come to the consideration of "the subject matter" of Letters Patent, and if difficulties met us at the threshold as to who could be defined as the "true and first inventor," we are here almost hopelessly entangled and bewildered in the multitude of exceptions and reservations which beset this section of the law. Our author has devoted a lengthy chapter to the matter, at the commencement of which he says: "It will be convenient to consider, first, what amount of publication and user will invalidate a patent; secondly, what constitutes a 'new manufacture,' within the meaning of the statute; and thirdly, whether the invention is useful, which is a condition imposed by the common law and not by the statute" (p. 11).

If a description of an invention has been printed in a book, and that book has been exposed for sale—which constitutes technically the act of publication, for this purpose actual sale being not necessary—a subsequent patent for this invention is invalidated thereby. In the same way also if an invention has been described in a specification, the subsequent patent is vitiated even if there be some difference in the mode of working—a specification being held not to differ from any other publication. It is important, however, to note here that "the amount of information, given by a prior publication in order to avoid a subsequent patent, must be equal to that required to be given by a specification, and must be enough to enable the public to carry the invention into practical use" (p. 17).

No valid patent can be granted for an invention which has already been publicly used or generally known, and a very slight amount of user is enough to vitiate a patent, provided that it is really public. It is well known, however, that the exhibition of inventions at international exhibitions is not held to constitute public user.

Public user is of course distinct from experiments conducted in private to test an invention, and from secret manufacture by the inventor before patenting, but if such experiments be conducted in a place accessible to the public or if there is sale of the articles manufactured before patenting, it is held to be public user, and a subsequent patent is vitiated. "If," however, "an experiment towards an invention is made, and fails, and is abandoned, the invention of a subsequent in-

[1] *The Law and Practice Relating to Letters Patent for Inventions, together with notices of the Patent Laws in force in the principal Foreign States and in the Colonies, with an Appendix containing the statutes, rules, &c.* By William Fischer Agnew, of Lincoln's Inn, barrister-at-law. London: Wildy and Sons; Manchester: Meredith and Ray; Edinburgh: Bell and Bradfute; Dublin: Hodges, Foster and Co. 1874.

ventor, who in effect remedies the defects, in the first invention, though he has never seen it, will not be vitiated by the previous user" (p. 28).

The accidental user of a piece of machinery, or an accidental combination of materials, will not vitiate the patent, but if there be user for private purposes, there will nevertheless be such public user as to defeat a subsequent patent. The question of public user, however clearly defined, is after all one of fact for the jury to decide, and as our author remarks, "The question whether or not the manufacture was in public use in England before the date of the patent, or whether the evidence only shows that experiments have been made, which have been abandoned, is one of considerable delicacy; a slight alteration in the effect of the evidence will establish either the one proposition or the other, and the only proper mode of deciding it, is to leave it to the jury; and if they hear the evidence patiently, and apply it with intelligence, their verdict will not be disturbed" (p. 32).

Another delicate point, and one on which important questions must often turn, is the meaning of the word "manufacture," which has often been discussed, and by nearly all the authorities. The following remarks of Chief Justice Eyre on this subject will be read with interest:—"According to the letter of the statute, the saving goes only to the sole working and making; the sole buying, selling, and using remain under the general prohibition. It was admitted that the word 'manufacture' in the statute was of extensive signification, that it is applied not only to things made, but to the practice of making, to principles carried into practice, in a new manner; to new results of principles carried into practice. Let us pursue this admission. Under things made, we may class in the first place new compositions of things, such as manufactures in the most ordinary sense of the word; secondly, all mechanical inventions, whether made to produce old or new effects, for a new piece of mechanism is certainly a thing made. Under the practice of making, we may class all new artificial manners of operating with the hand, or with instruments in common use, new processes, in any art producing effects useful to the public" (pp. 33, 34). "Manufacture" then clearly means, either the machine or the mode of constructing it—the amount of labour, thought, or money bestowed upon it being immaterial.

The mode or process of manufacture, apart from things produced, is now considered, although at one time this was not so, to be a good subject matter for a patent.

"A method of performing a process," said Justice Rooke, "means the mode or manner of effecting. A newly invented method, therefore, means the idea of a new mode of construction." And Justice Heath said that, "when a mode of doing a thing is referred to something permanent it is properly termed an engine; when to something fugitive, a method" (p. 40).

Another important point is, that a patent cannot be granted for a bare principle only. "The leading case on this point is Boulton v. Bull. The patent was for 'a method of lessening the consumption of steam and fuel in the fire-engines.' The specification commenced by saying, 'My method of lessening the consumption of steam, and consequently fuel, in fire-engines, consists of the following principles,' and then describes how they were to be carried into effect. The patent was objected to on the ground that a patent could not be granted for a principle, and "the judges differed as to the construction of the specification, but they all agreed that there could be no patent for a principle" (p. 41).

It is, then, clearly laid down that a philosophical abstract principle cannot answer to the word manufacture, and cannot therefore be patented, but a patent may be granted for a mode of applying a principle to some machine or process. The skill of the inventor, which is to be rewarded, is shown, of course, in the application of principles. "You cannot take out a patent for a principle; you may take out a patent for a principle, coupled with a mode for carrying it into effect, provided you have not only discovered the principle, but invented some mode of carrying it into effect" (p. 42).

If, however, in the specification, the mode or method of applying the principle be not pointed out, the patent will be for the principle only, and invalid; and on the other hand, if every mode of carrying the principle into effect is claimed for the patent, this also is a patent for the principle only, and is vitiated.

If an addition to, or an improvement in, existent and already patented machines be new and of benefit to the public, it is a good subject-matter for a patent. The value of such addition or improvement is, however, a question for the jury. Patents may also be granted for combinations of known articles, either old or new, in a novel manner, but the application of an old machine to analogous purposes to those for which it has already been used, or to new materials, cannot be patented unless the mode of application is new. Nor can a patent be taken out for the use of an old and disused machine in the old manner.

The application of known machinery and new matter cannot also be patented, but the adaptation of known substances to new purposes may be the subject of a patent.

From what has been said, it will be seen that the invention must not only be complete and new, but utility is requisite—the amount of utility is not considered—it is sufficient if this quality exists at all. But both of its novelty and utility the jury alone must decide, and it is admitted that the fact of an invention not getting into use is a presumption against its utility.

We now pass to the consideration of the first step to be taken by the inventor preliminary to securing his patent, viz. the preparation of the specification. What this should be is very clearly defined by Mr. Agnew; and at the commencement of the section of his book which treats of this subject, the object of the specification is shown to be twofold. It is the price which the inventor pays for the privileges accorded to him by the patent, and it is intended not only to describe the invention so that the authorities may decide whether or no it is a patentable one, but it must also be so worded as to enable a workman or workmen to make it up therefrom, so that the public may have the full benefit of the discovery when the term has expired. The specification must perfectly describe the invention, clearly, unmistakably,—and superfluous descriptions, as well as insufficient ones, if they interfere with the utility of the specification as enabling the invention to be worked from it by other than the inventor, are held to vitiate the patent. Omissions of any part of the process, or ambiguity in the wording, are held to be bad; but upon this section it does not seem to us to be necessary to dwell at length, the principle which should govern the compilation of the specification being, as we have indicated, a very clear and definite one.

If a specification has been made void by reason of the introduction of unnecessary matter, the inventor may enter a disclaimer of such portion of the specification, and under the head of "Disclaimers" this matter is treated of at due length.

The method of obtaining letters patent is a chapter of great importance, and we shall refer to this more particularly, contenting ourselves with merely enumerating the titles of the rest of the chapters in the book, from which our readers will see that it is complete in every matter touching this most complicated and intricate law.

The Office of the Commissioners, the Extension and Confirmation of the term of letters patent, Assignments, Licenses, infringement, and actions for infringement, suit in equity, &c., are all dealt with; but these latter sections of the subject are of far too legally technical a nature for us to do more than refer to them here, and we shall now speak more in detail of the chapter on the mode of obtaining letters patent.

"The first step for an applicant for letters patent to take is to petition the crown for a grant. The petition states that the petitioner is in possession of an invention (naming it); that he believes it will be of great public utility; that he is the first and true inventor; and that it is not in use by any other person or persons to the best of his knowledge and belief. The application must be for one invention only. The petition is accompanied by a declaration in support."

A special declaration has to be made where a patent is communicated from abroad. The petition and declaration must be accompanied by a provisional specification. The provisional specification must be distinct, and for one invention only.

The forms for the purposes of such application are easily obtainable, and the sizes on which these are to be written, with other information, can be learned with facility.

The law officer of the crown then deliberates upon the specification, and if he is satisfied that it describes the invention, he will issue a certificate protecting it for six months.

"The title of the patent must point out distinctly and specifically the nature and objects of the invention. Every patent must stand on the ground of improvement or discovery. If of improvement, it must stand on the ground of improvement invented; if of discovery, it must stand on the ground of a discovery of something altogether new: and the patent must distinguish and adapt itself accordingly. If the patent be taken out for discovery, when the alleged discovery is merely an addition or improvement, it is scarcely necessary to observe that it will be altogether void (pp. 145, 146). The title must also give some idea, and so far as it goes a true idea, of the alleged invention. An indistinct title is sufficient to invalidate the patent, but if the law officer is of opinion that the title fails in respect of being either too comprehensive or insufficiently descriptive, he may allow or require it to be amended.

The complete specification, which may either take the place of the provisional specification or be filed (the filing is absolutely necessary) afterwards, must be a description of the same invention as the provisional specification, although the complete specification need not extend to everything included in the former.

On the other hand, so long as the provisional specification describes the invention with sufficient accuracy, it need not enter so minutely into detail as the complete specification; and the former cannot be read for the purpose of interpreting the complete specification.

After these steps have been taken, and the applicant determines to proceed with his application, the application is advertised, so as to give an opportunity to those persons who may have an interest in opposing the grant to come forward for the purpose of doing so. It is, of course, at this juncture that the applicant's troubles may begin, and here may come in the necessity for reference to the chapters of the book to which we have alluded above, and on which, as we have indicated, we do not propose to dwell.

It is important to note that nothing in the Act can abridge or affect the prerogative of the crown in withholding letters patent, and in some cases Government has the power to order that certain patents may be kept secret.

Within the limits of this short paper we have not, of course, attempted anything like a complete exposition of the law with which Mr. Agnew so lucidly deals. We have merely endeavoured to point out some of its more prominent features; but the numerous and, apparently, inexhaustible reservations and exceptions which beset every section of the Act, compel us to insist most strongly that everyone who wishes to acquaint themselves with the law should refer direct to Mr. Agnew's valuable book.

QUANTITIES AND MEASUREMENTS.[1]

THE fact that this book has reached a fourth edition places any criticism of it by us at this time entirely out of the question, the trades and professions for which it is intended, having by the practical appreciation of its value which they have shown, stamped it already as a standard book.

It is adapted for students, practical men, masters, and workmen, as well as for young men who are training for their profession, and its conciseness, completeness, and the compact form in which it is issued, render it indispensable to the long list of professional men and others which are enumerated on the very copious title-page which we have given below.

It is important to note that in the new edition the price lists are prepared with careful minuteness, and have been revised and brought down to the present time.

THE SAFE USE OF STEAM.[2]

THIS is a popularly written little tractate, published at a low price, with the very laudable intention of adding to the safeguards against such accidents as steam-boiler explosions, by imparting "to the steam user himself a knowledge of the safe and economical working of steam boilers which will be his best insurance against the ignorance of those whom he may employ."

We all know that "accidents will happen in the best regulated families," and the best regulated boilers sometimes explode, but it cannot be doubted, nevertheless, that many of the disastrous accidents that do happen to steam boilers are to a great extent the result of the inattention, recklessness, and ignorance of their attendants, and while we have no doubt that this pamphlet may be found to be of real service in enlightening the master, we feel certain that the only efficient means of reducing such accidents to a minimum is to employ only those attendants who understand their business and are of a thoroughly trustworthy character.

[1] *Quantities and Measurements: How to calculate and take them in Bricklayers', Masons', Plasterers', Plumbers', Painters', Paperhangers', Gilders', Smiths', Carpenters', and Joiners' Work. With Rules for Abstracting, Hints for preparing a Bill of Quantities, and Prices for all work in the Building Trade.* By Alfred Charles Beaton, Architect and Surveyor. Fourth Edition, Revised and Enlarged, with the prices corrected to the Present Date. London: Lockwood and Co. 1874.

[2] *The Safe Use of Steam: containing Rules for the Guidance of Unprofessional Steam Users.* By an Engineer. London Lockwood and Co. 1874.

EARTHWORK TABLES.[1]

THE title of this compilation indicates its nature and scope with so much precision, that there is little need for us to do more than to recommend it to all to whom such a set of tables is likely to be of service.

The compilers would seem to have achieved the result which everyone who brings a new set of tables before his profession should attain, viz. that of giving the greatest amount of utility in the smallest possible space, and we have no doubt that they will be found extremely valuable in facilitating the precise determination of earthwork quantities in estimates for permanent work. The heights and depths are given in feet, progressing by increments of one-tenth of a foot, so that the smallest results, as well as the largest, can be determined with accuracy.

TABLES FOR TRAVELLERS.[2]

THIS little book is truly a *multum in parvo*, and is a marvel of conciseness of arrangement; for within the compass of between eighty and ninety 16mo. pages, is given a mass of information of all kinds likely to be of value to travellers, by land or sea, in making and recording their calculations and observations which, from the table of contents, it would appear to need a huge octavo volume to contain. Every inch of space is utilized; even on the title-page is printed a diagram of the sphere, on which the circles are drawn ten degrees apart, in order that it may be useful to those who have not practised "construction."

The book is intended to supply a want which is no doubt often felt by travellers when separated from their larger and more comprehensive works, and this they certainly may have always with them, for it can be kept in the sextant-case, which Admiral Bethune recommends should be fitted to contain artificial horizon, &c., so as to be ready for any emergency, and thus to enable the traveller to determine his position, so far as sun and stars are concerned, with considerable accuracy.

A brief enumeration of the contents of this handy and invaluable little volume will suffice to show the reader that it contains almost everything in the way of tables which the traveller may find needful, although, as the compiler states, it must "be borne in mind that, as in the application of machinery, power is gained by a sacrifice of velocity, so conciseness must be purchased by additional calculation." Eighteen tables are given with very clear and precise explanations and examples of their uses. These are traverse tables; sun's apparent right ascension and declination; sun's mean right ascension; arguments for lunar and planetary corrections; 1st correction of argument M; 2nd correction of M and solar nutation: lunar correction: lunar nutation; factors $\frac{da}{d\odot}, \frac{da}{d\omega}, \frac{d\delta}{d\omega}$; sum of planetary corrections until 1900; general table of planetary corrections; right ascension and declination of ninety fixed stars; aberration; nutation; refraction; logarithms, 100 to 1,000; sines and log. sines for each degree; tangents and log. tangents for each degree. To which are added a synopsis of trigonometry; differentials; mensuration; formulæ of arithmetical and geometrical progression, permutation, combinations, evolution, and piles of shot; a list of specific gravities; method of calculating the tide hour, or *establishment*, and of reckoning the calendar.

[1] *Earthwork Tables, showing the Contents, in cubic yards, of Embankments, Cuttings, &c., of heights or depths, up to an average of eighty feet.* By Joseph Broadbent and Francis Campin, Civil Engineers. London: Lockwood and Co. 1874.

[2] *Tables for Travellers, adapted to the Pocket or Sextant-case.* Compiled by Admiral Bethune, C. B., F. R. A. S., F. R. G. S. Second Edition. Edinburgh and London: William Blackwood and Sons. 1874.

Foreign Practical Journals.

Zeitschrift des oesterreichischen Ingenieur- und Architekten-Vereines. Heft xv. Wien, v. Waldheim.

IN 1870 the Hungarian government engaged the French engineer, Pascal, to undertake the works of the harbour improvements at Fiume, on the Adriatic, the principal port of Austria. The system adopted was that of lowering large blocks of artificial stone, containing each 11·1 cubic metres. The works are now in full activity, and are described in illustrated detail by J. Wilfan.—The principles of German railway construction are given by L. Winkelblech.—Herr Heyne has a letter written from London, in which familiar objects are invested with a fresh interest.

Oesterrischisches Landwirthschaftliches Wochenblatt. Wien, Faesy & Frick.

A NEW Austrian agricultural weekly, of which we have received the specimen number, dated for Jan. 2, 1875. It contains a close study of the unpleasant-looking *Phylloxera vastatrix* ("Wurzellaus"); a description of Garrett's potato-setter; papers on acclimatization, and a large number of miscellanea. English agricultural machinery has a good share of the attention of this paper.

Le Technologiste. No. 406. Oct. 1874. Paris, Roret.

TEQUESQUITE, a sodic and potassic alkaline salt, native to Mexico, is analyzed by M. Chateau, who also supplies a study on vegetable waxes from the *Myricæ*.—The composition is given of Pirsch-Baudoin's alloy to imitate silver.—M. Caillé has a series of notes on the elasticity of railway lines.—In translating our article on Hock's petroleum motor, the editor takes occasion to defend Lenoir's gas-engine, of which Hock's is argued to be an adaptation.—The effects of variation in work on machines, the employment of black lead instead of oil as a lubricant, and Gasselin's apparatus for the saving of life at sea, conclude the number.

Bulletin de la Société chimique de Paris. Nov. 20, 1874. Paris, G. Masson.

AMONGST the papers read before the Paris Chemical Society, is one by Debray, on the dissolution of hydrated salts; by Berthelot, on the preparation of crystallizable formic acid; by Bourgoin, on the preparation and properties of dioxymalic acid.—M. Longinine gives an abstract of the *Journal de la Société chimique russe* for September; ozone is produced in the combustion of certain illuminating materials, wax, stearine, magnesium; a new general formula for gases is submitted, and an apparatus for the condensation of gases, chlorine, ammonia, &c.—Sections follow on organic, agricultural, and technical chemistry.

Bulletin de la Société industrielle de Rouen. July, Aug., Sept., 1874. Rouen, Léon Deshays.

THE following papers were read before the society in the period from July to September last: On the decoloration of aniline black, by the use of oxide of manganese—On the production of aniline blacks and greys of an exceptional resisting power—On the variations in coal of different districts—On a self-acting furnace register—On a new machine to print cottons, &c., in eight colours at once (the first made in Rouen). It requires a service of 12-horse power. Report on an analysis of the calcareous incrustations found in steam boilers—Report on the creation of a museum of industrial design, to be permanently fixed at Rouen, and to aid in the development of design in the staple trades of Rouen. The museum is now in fair way of being founded.

Gaceta industrial. Nos. 429-435 (Nov. 19). Madrid, Alcover.

A RIBBON saw, for small woodwork, by Arbey, of Paris, is described.—J. R. Sitges reports upon the "Exposicion Betico-Extremeña," held in the Alcazar at Seville, and recently closed. In the industrial section there were 227 exhibitors, the firm of Portilla, White and Co. being the most important and the most successful. A "memoria" of this exhibition was drawn up by its secretary, D. J. Collantes de Terán, and has just been issued.—Apropos of the erection of a new velvet-weaving establishment in Barcelona, Don Alcover remarks that some industries, carpet-weaving, glass-making, pottery, cotton, are completely lost to modern Spain, not only on account of political difficulties and the want of enterprise on the part of producers, but also for the want of patriotism—*españolismo*—on the part of the upper classes of society.

L'Economista. Nov. 1874. Florence and Rome.

A GOOD account is given of the system now existing of public instruction in England, useful for those who are interested in the question of popular technical education.—The "*Economista*," in a succeeding article, deprecates State interference in education, building arrangements, &c.—Other matters are: The Italian public debt; account of State railways; Austrian machines in the Italian market; the international railway congress; the Italian treasury; products of the Italian telegraph lines in the first nine months of 1874, the congress of economists at Milan; the condition of the ports of Trieste, Venice and Genoa, after the opening of the Suez Canal.

Moniteur industriel belge. Brussels, Jules Meeûs.

CONTAINS:—A study on lightning conductors, by M. Melsens; the situation of the great metal-working establishments of France in 1873; iron-working in Roumelia; the conditions for the prize of 10,000 fr. offered jointly by the Belgian government and a member of the Association of Engineers, to any person devising a system of working coal-mines with the smallest amount of danger from fire-damp.

Techneshesky Slovnik (Russian Technological Gatherer, an illustrated journal of discoveries, inventions and improvements in all branches of industry).

THE September number of this cheap and useful periodical, now in its tenth year of existence, has a good selection of papers on various subjects connected with industrial pursuits. M. Valkoff contributes short papers on the sequestration from towns of noxious trades, on disinfectants, and on meat-preserving, for the latter recommending Nessler's process. M. Geller describes a method of manufacturing brandy from millet, tried by him last year, at a distillery belonging to Count Stroganof. The yield is somewhat less than that of rye treated in the same way, but the cheapness of the grain, which is only half the price of rye, and the fair quality of the spirit, make the process remunerative. M. Antoshin figures a wood-planing machine. An account of Professor Thurston's experiments on the resistance of metals, and a description of Capt. Ericsson's compressed-air engine are copied from American sources. There is also an article on Hops, taken from the *Dictionnaire des Arts, manufactures et l'agriculture;* and numerous short extracts from recent numbers of *Dingler's Polytech. Rev. Revue Industrielle*, and other journals.

CENTENNIAL EXHIBITION, PHILADELPHIA, AMERICA, 1876.

OUR engraving is a view of the building destined to contain the exhibition of arts and industry in commemoration of the 100th anniversary of American independence. The buildings cover a floor space of about forty acres, and are divided into the main building, art gallery, machinery hall, and agricultural and horticultural halls. The art gallery is separated from the main building by a space 300 ft. wide, which will be devoted to special purposes and laid out ornamentally. The main building is in the form of a parallelogram, and for the most part one storey high, the main cornice on the outside being 45 ft. from the ground. At the centre of the longer sides are projections 416 ft. in length, and in the centre of the shorter sides or ends of the building are projections 216 ft. in length. In these projections, in the centre of the four sides, are located the main entrances, which are provided with arcades upon the ground floor, and central façades extending to the height of 90 ft.

The main portal on the north side communicates directly with

the art gallery, and the main portal on the west side gives the main passage way to the machinery and agricultural halls.

Upon the corners of the building there are four towers 75 ft. in height, and between the towers and the central projections or entrances, there is a lower roof introduced showing a cornice at 24 ft. above the ground.

In order to obtain a central feature for the building as a whole, the roof over the central part, for 184 ft. square, has been raised above the surrounding portion, and four towers, 48 ft. square, rising to 120 ft. in height, have been introduced at the corners of the elevated roof.

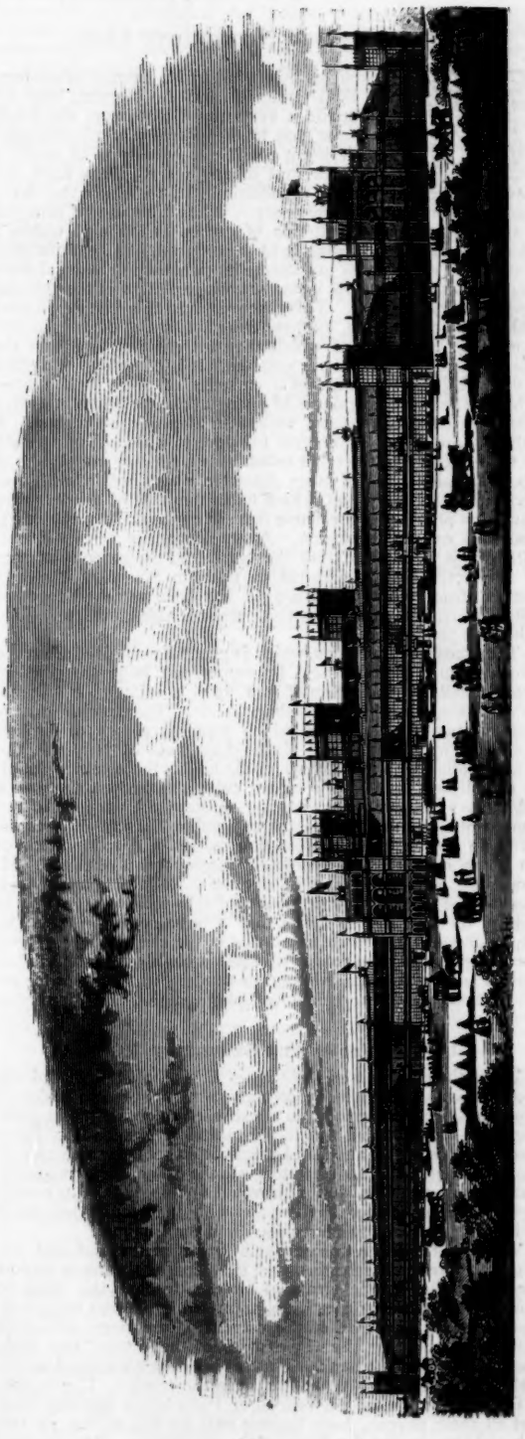
In order to break the great length of the roof lines, three cross avenues or transepts have been introduced of the same widths and in the same relative positions to each other as the nave and avenues running lengthwise. The intersections of these avenues and transepts in the central portion of the bnilding result in dividing the ground floor into nine open spaces free from supporting columns, and covering in the aggregate an area of 416 ft. square. Four of these spaces are 100 ft. square, four 100 ft. by 120 ft., and the central space or pavilion 120 ft. square. The intersections of the 48 ft. aisles produce four interior courts 48 ft. square, one at each corner of the central space.

The main promenades through the nave and central transept are each 30 ft. in width, and those through the centre of the side avenues and transepts 15 ft. each. All other walks are 10 ft. wide, and lead at either end to exit doors.

The following are the principal dimensions of the different parts of the building :—

Length of building	1,880 ft.
Width of building	464 „
CENTRAL AVENUE OR NAVE.	
Length	1,823 „
Width	120 „
Height to top of supporting columns	45 „
Height to ridge of roof	70 „
CENTRAL TRANSEPT.	
Length	416 „
Width	120 „
Height to top of columns	45 „
Height to ridge of roof	70 „
SIDE AVENUES.	
Length	1,832 „
Width	100 „
Height to top of columns	45 „
Height to ridge of roof	65 „
SIDE TRANSEPTS.	
Length	416 „
Width	100 „
Height to top of columns	45 „
Height to ridge of roof	65 „
CENTRAL AISLES.	
Length at east end	744 „
„ at west end	672 „
Width	48 „
Height to roof	30 „
SIDE AISLES.	
Length at east end	744 „
„ at west end	672 „
Width	24 „
Height to roof	24 „
CENTRE SPACE OR PAVILION.	
Ground plan	120 ft. square.
Height to top of supporting columns	72 „
Height to ridge of roof	96 „
TOWERS OVER COURTS.	
Ground plan	48 ft. square.
Height to roof	120 „
CORNER TOWERS.	
Ground plan	24 ft. square.
Height to roof	75 „

The foundations consist of piers of masonry, and the superstructure is composed of wrought-iron columns supporting wrought-iron roof trusses. As a general rule the columns are placed lengthwise of the building, at the uniform distance apart of 24 ft., and the sides of the building for the height of 7 ft. from the ground are finished with timber framed in panels between the columns, and above the 7 ft. with glazed sash. The wrought-iron columns are composed of rolled channel bars with plates rivetted to the flanges. The roof trusses are similar in form to those in general use for depots and warehouses, and consist of straight rafters with struts and tie-bars.



Special Correspondence.

PARIS, *November* 21, 1874.

PHOTOGENIC AND PHOTOGRAPHIC LAMP.

TWO chemists belonging to M. Dumas' laboratory, MM. B. Delachanel and A. Mermet, have together made a very useful discovery, which will open a new way to the practice of photography, by rendering it possible to operate at all seasons, at any hour, and in any place. They have discovered a new photogenic or actinic light, to which they have succeeded in giving permanency. When binoxide of nitrogen containing vapour of sulphide of carbon is inflamed within a glass phial, a most dazzling light is produced, of a beautiful blue tint, which would seem to indicate its richness in chemical rays, and in fact it causes the instantaneous explosion of the chlorine and hydrogen mixture. This discovery and this first experiment led to the construction, by these two chemists, of the sulpho-carbon lamp, by means of which they are enabled to obtain the above flame in a continuous manner. It is composed of a glass bottle with two tubulures, of a capacity of about half a litre. This is filled with fragments of spongy coke, or better still with bits of dried pumice-stone, soaked in sulphide of carbon. A tube passes down the central tubulure to within about $\frac{1}{4}$ inch of the bottom. In the other tubulure is a glass or metal tube of about 8 in. long and of large diameter, which is filled with iron turnings strongly packed, which fulfils the part of a safety wire gauze, by preventing the flame from flying back into the reservoir and causing explosion. A small quantity of binoxide of nitrogen is introduced into the bottle and the gaseous mixture is conducted by an india-rubber tube to a sort of Bunsen's burner, from which the gas-pipe has been removed together with the conical regulator; this burner is also completely filled with iron turnings.

The binoxide of nitrogen, which is generally obtained from the decomposition of nitric acid by copper, can be produced more economically by the action of iron upon a mixture, in suitable proportions, of nitric and sulphuric acids. The apparatus consists of two flasks, one of which contains pieces of broken porcelain upon which are placed fragments of bar iron, the other is filled with the mixture of the acids; the communication is established by a thick rubber tube attached to the lower tubulures; lastly, a cock, passing through the stopper of the flask containing the iron, serves to regulate the exit of the gas. With an apparatus of suitable dimensions, a dazzling flame of 10 in. in diameter and absolutely continuous is obtained. M. Frank de Villecholes, one of our most skilful photographers, asserts that the photogenic power of this flame is superior to that of the magnesium light; that it is twice as great as the oxy-hydrogen, and three times that of the electric light. These combined advantages render it highly probable that the sulpho-carbon lamp will be called upon to render great services for reproductions and enlargements of photographs, and for microscopic objects, &c. &c.

UTILIZATION OF THE SEWAGE OF PARIS.

When the engineers of the City of Paris had terminated the construction of the great collecting sewer, supposed to be one of the wonders of the world, and which used to be visited in great pomp by illustrious visitors to the capital of France from every quarter of the globe, and had brought it down as far as Asnières, there to disgorge its turbid waters into the Seine, they innocently imagined that this flood of filth would obligingly take its course along the right bank of the river, and with due docility flow down to its mouth and there empty itself into the Channel.

We do not hesitate to say that in doing so they ignored the first principles of mechanics, and even forgot the fundamental theorem of the parallelogram of forces. In fact, this flood of sewage upon entering the Seine, animated by its own impulsion and receiving also that of the current of the river, traversed diagonally, polluting the whole mass of the waters, and took possession of the left bank. This was at once an unpardonable error and a disaster. What has been the result? The waters of the Seine in the neighbourhood of Paris below Asnières have lost all their oxygen, have become unfit for life, killing all the fish and threatening the lives of the population. This serious evil demanded a prompt remedy, but this would have demanded of the City of Paris a sacrifice beyond its powers, and it was therefore fatally compelled to be satisfied with gradually attacking the difficult problem of sending the sewage into the river only after it had been deprived of the organic matters it contained. That is now what is endeavouring to be done in the plains of Gennevillers, and the preliminary works of which I shall endeavour to describe to my readers across the Channel.

The net-work of the sewers of the city of Paris extend actually to a length of 373 miles. Following all the roadways on each side of the river, it brings together the domestic sewage and the waterings of the town into three grand collectors: 1st, that of the left bank, which traverses the Seine by means of a syphon a little above the bridge of the Alma; 2nd, that of the right bank, which after having received the sewage of the left bank as above stated has its outlet below the bridge of Asnières; 3rd, that of St. Denis, which after receiving the waters of the Bondy dust-yards, collects all those of Belleville, of La Chapelle, of the northern slope of Montmartre, and of Saint Denis, and at last falls into the Seine at Saint Denis between the suspension bridge and the canal.

The volume of water daily thrown out by the grand collector at Asnières, is about 216,604 cubic yards; and by the collector at Saint Denis about 52,321 cubic yards, making together a daily total of about 313,925 cubic yards, which is equal to about one-twentieth of the total delivery of the Seine when the water is at its lowest level.

The waters of the grand collector contain on an average per cubic metre (1·308 cubic yards) about 5 lbs. of various matter, of which one half is solid detritus held in suspension, and the other half essentially fertilizing soluble substances, in which are contained 1 oz. 19 grains of potash, 1 oz. 183 grains of nitrogen, and 108 grains of phosphoric acid.

The waters of the Saint Denis sewer are much more heavily charged; they contain per cubic metre 9 lbs. 6 oz. of solid matter, in which the quantity of nitrogen amounts to $4\frac{1}{2}$ oz., with about 2 oz. 104 grains of potash and 1 oz. 384 grains of phosphoric acid.

Altogether a quantity of about 300 tons of eminently putrescible solid matter is daily thrown into the river at Asnières, which there forms on the Clichy side a bank of infectious ooze, which would in time become sufficient to obstruct the bed of the river and interfere with the navigation when the waters are low, if it was not daily removed by permanent dredging, which does not cost less than £8,000 per annum.

Several methods have been proposed to obviate the intolerable inconveniences and the serious dangers which thus threaten the populations on the banks of the Seine, from the pollution of its waters by the sewage of Paris.

Filtering was at first proposed; but it was soon found to be impossible to apply it efficiently. It is easy enough to filter a few cubic yards of water, but 313,925 cubic yards is quite a different matter. And how to clear the filters of 300 tons of solid infectious matter which would daily obstruct them? Besides, the process of filtering would leave all the soluble putrescible matter in the water, and would therefore not prevent the pollution of the river; its only effect would be to prevent obstruction. This idea was therefore abandoned.

Another very ingenious proposal, was to apply the Indian process for the clarifying of muddy waters, by means of alum. M. Le Chatelier has tried this process upon a sufficiently extensive scale: 100,000 cubic metres (130,802 cubic yards) of sewage was treated by sulphate of alumina, and the waters being allowed to rest soon became clear, leaving a sufficiently dense precipitate, which was equal in fertilizing properties to its own volume of good farmyard manure. This process, which would only cost one centime per cubic metre of sewage, would still require for the complete clarification of all the sewage of Paris, a daily expenditure of £96, or £37,440 per annum. There would still remain 300 tons of offensive detritus to be removed every day and distributed as manure, and the *clarified* waters would even then be far from *purified*. The treatment of sewage by lime is open to the same objections, and hitherto these liquids have only succeeded in fertilizing the pockets of speculators. Many small towns in England have nevertheless succeeded in realizing an agricultural use of sewage. They are 44 in number, with an average population of 12,500 inhabitants. The same system has been adopted in Russia, in Germany, and in Belgium; it is therefore reasonable to suppose that it presents the means of really disposing of the important question of public health which relates to the sewage of large towns.

Those manufacturers to whom waters charged with putrescible matter are a source of continual annoyance, expense, and even law-suits, would do well to study the great experiment which has been made in the plain of Gennevilliers. Catgut spinners, white leather dressers, knackers, soap boilers, candle makers, paper makers, &c. &c., might often utilize their waste waters for agricultural purposes; therefore new factories ought as much as possible to be established above barren plains, in order to fertilize them by means of irrigation canals. Two and a half acres of sandy soil just outside of Paris absorb yearly 50,000 cubic

metres (65,410 cubic yards) of sewage water, and are thus converted into land of marvellous fertility.

We have just learned that M. Elie Toliclerc, who had already obtained admirable results of vegetable culture at Gennevilliers upon the soil irrigated by the sewage of Paris, has obtained a concession from that city, and that he is in treaty with an English company for the necessary capital, the object of the enterprise being—1st, to purify the sewage; and 2nd, to employ its fertilizing properties upon the plain of Gennevilliers, between Asnières and Saint Denis.

This is the same project as that of the A B C Company, which would undoubtedly have been successful if the promoters, particularly M. Belgrand, had succeeded in coming to an understanding with the Municipal Council of Paris.

M. Mouret's Sphere.

Representation of the terrestrial globe, and of its annual movement in its orbit, and of the phenomena which are occasioned thereby.—That part of the study of cosmography or of physical astronomy in connection with the earth, which is the most important to us is, without doubt, that of the globe upon which we live, with its flattened spheroidal form, which may be represented by a sphere, with its configuration or local distribution of continents and seas upon its surface, with its change of position, at one moment accelerated, at another retarded along its immense elliptical orbit, fulfilling at the same time the essential condition that its axis be always rigorously parallel to itself. All the principal or secondary phenomena of cosmography, the part of the globe illuminated, and that part which is in the shade, the break of day and twilight, mean time and true time, the seasons, climates, &c. &c., all derive their cause and explanation from the displacement of the earth in space thus defined.

In all times a desire has been felt and expressed to be able to realize artificially, by means of a globe, a sufficiently exact reproduction of the sidereal movement, and to represent to the spectator those phenomena which constitute the exterior life of humanity. It was not absolutely impossible to cause a globe to revolve in an orbit resembling that of the earth, and fulfilling the same conditions of displacement and of the rigorous parallelism of the real terrestrial axis; but in order to effect this displacement of the globe in space, it was necessary that the cosmographic apparatus should be of a complicated nature, should occupy a considerable space, and become of course very expensive. But even this could only constitute an approximative solution, which still left too much play to the imagination.

Notwithstanding numerous attempts, there still remained a very beautiful and very difficult problem to solve, a great invention to be realized, a profound secret to be discovered, a veritable Gordian knot to be severed. This is what M. Mouret has succeeded in doing by following a new and most luminous idea, which I will endeavour to explain in a few words.

The axis of the earth describes in space a single hyperboloid, of which the neck circle is the terrestrial orbit considered as circular. If it were possible to reduce this hyperboloid to a double cone, the problem would then be to cause a line fixed at its centre to revolve in three hundred and sixty-five days and a quarter, and this would present no difficulty. Besides, to reduce a hyperboloid to a cone, it is only necessary to reduce its neck circle to a point, the intersection of all the edges of the hyperboloid reduced to a right cone. This is what M. Mouret has succeeded in doing by a most ingenious idea, which he calls the theory of the double cone.

Let us suppose, as he says, that a spectator be placed a-straddle on the vector radius leading from the earth to the sun, with his back to the sun, and that, supplied with a powerful telescope, he constantly observes in space, not the terrestrial globe, but its perpendicular axis north and south, and its equator oblique to the ecliptic, following it in all its positions, having it always in view, no longer parallel to itself, but passing always through the earth's centre. It is evident that to him the diameter of the terrestrial orbit will disappear; the neck circle of the hyperboloid will be reduced to a point, and the hyperboloid to a double cone; of which the southern cone will have its point upwards, and the northern cone its point downwards, with their common axis perpendicular to the plane of the orbit. If therefore by means of clockwork we cause the solid axis of a terrestrial globe fixed at its centre to describe the double cone of which we have spoken in three hundred and sixty-five days and a quarter, this axis will cause the globe to revolve in those exact conditions of inclination and displacement of the earth itself, and the spectator who keeps his eye fixed upon it will observe all the phenomena of light and shade, of the seasons, of climate, &c., exactly the same as if he were seated in the sun and, provided with a gigantic telescope, were able to follow the production of these different phenomena by direct vision.

This is the beautiful problem which has been solved by M. Mouret. I did not decide upon becoming the echo of his discovery until it had been submitted to the examination of one of our most eminent artists, who has been long familiarized with the difficulties of cosmogonic mechanics, and at the same time with all the secrets of clock-making. M. Redier, already mentioned in these pages as the constructor of an automatically revolving sphere (see "Practical Magazine" for September), and who has himself realized so many ingenious and charming conceptions, was amazed at what he saw, and was kind enough to write me his impressions, which I am happy to reproduce:—

"The constructions already known," he writes, "resembling too much in this respect that which takes place in nature, require an apparatus of considerable magnitude; a globe moving in a real orbit, and presenting an axis constantly rigorously parallel to itself, which can only be obtained approximately, and renders the mechanism very complicated. M. Mouret, on the contrary, produces all the orbital movements and the appearances to which they give rise, without displacing his globe, which is always fixed at its centre. And that which is most remarkable and unexpected, he has succeeded in giving indications such as have never been produced on any other instrument of the kind.

"Thus the motion of his sphere for the first time gives the true time, while the clock which regulates the movement indicates mean time; and the passage of this mean time to true time is not effected by means of curves traced empirically, but by simple geometrical combinations.

"It is easy to obtain at any moment, and with equal exactness, the quantity of illumination and of shade, the duration of dawn and of twilight, the angle of solar declination and the perspective angle of the axis, the exact track of the two semi-annual helices described by the vertical radius, and the position of the vertical radius.

"From this all the climacteric indications and all the consequences of the sun's movement between the solstices can be deduced.

"We cannot do otherwise than encourage M. Mouret to persevere in his undertaking, and to take such measures as to enable the public shortly to profit by his invention."

M. Mouret, who with reason is most enthusiastic for his cosmograph, but who is more skilful in planning than in describing, had presented it to the Academy of Sciences, like all inventors, calculating upon a favourable report, which would have been of great assistance to him.

But the Academy, which the new, important, and unexpected fact of a clock for mean time indicating also at the same instant true time, ought to have interested, held its peace. Fortunately for the inventor, he met with a most amiable, active, and persevering gentleman, M. Lasnier, who generously extended a friendly hand to him, and we are most happy to hear that 100 of M. Mouret's spheres are now being constructed, and will shortly be placed at the disposal of amateurs. We count upon their signal success, for this apparatus, simple and portable, is the most complete solution of the greatest problem of cosmography. It readily and practically explains by evident visual demonstration those phenomena which the boldest imaginations had difficulty in mastering.

The Truffle Oak and Truffles.

Some astonishment may be manifested at my introducing here the subject of truffles, the favourite tuber of Parisian epicures; but I think that in doing so I am furthering the interests both of England and of France. During my travels in 1857 I happened to meet with a most eminently intelligent mountaineer, M. Ravel, of Montagnac, department of the Basses-Alpes, who had made a double discovery of some importance. He had found, first, that the truffle, that precious tuber, which is now paid for at the rate of 16*s.* a pound, grows in preference round the hairy roots of a peculiar species of oak, the *quercus pubescens*, or *quercus robur*, or *lanuginosa;* secondly, that the truffle grounds are frequented by a particular sort of fly, which M. Ravel supposed to engender the truffle by pricking the roots of the oak, in the same manner as the insect *cynips* is known to engender the gall nut by pricking the stalks of the leaves of the oak. This genesis of the truffle has, however, not been confirmed; it is more probable that the truffle fly does not engender the tuber, but that it is attracted by the perfume, and that it deposits its eggs in it, which becoming developed later, cause its decomposition. But the theory of the truffle oak remains, and constitutes one of the conquests of science. It is absolutely certain that the truffles grow better and in greater abundance at the foot of the pubescent oak than anywhere else, and this fact has already become the starting point of an important industry. Already in the neighbourhood of Montagnac nearly 1500 acres have been planted with these oaks, and the produce in truffles has fully answered the expectations of the planters. M. Ravel has himself planted extensively, and he

has found that a small piece of ground of only about three acres and a-half has given him within a few years over £500 worth of truffles, and he told me a few days ago in Saint Denis that he would not take £100 for the present year's produce of the same piece of ground. Here is fortune, and within easy reach! Montagnac is but a few miles from Riez, in a most picturesque district, and possessing a mild and delicious climate. It is situated in the midst of a high table land of from nine to twelve miles in diameter, the soil of which, at present barren, is admirably adapted to the growth of the *quercus pubescens*, and consequently of truffles. This is what I therefore beg to lay before English capitalists, to go and seek these incomparable truffles from the department of the Basses-Alpes, as they seek their fine wines from the Gironde, from Sicily, from Madeira, and from Spain or Portugal. There are splendid operations to be made; M. Ravel will furnish all necessary information, and will supply acorns or young plants if required. In five or six years the trees will have engendered the truffles, the produce will be abundantly remunerative, and will pay largely all expenses of plantation, &c. The truffle oaks must be planted at some distance from each other, in rows the same as in orchards. Nothing would prevent other fruit plants or vegetables from being planted between them in the commencement, so as to cover a portion of the first outlay.

As a condiment, or to enrich the flavour and add to the nutritive qualities of many kinds of food, the truffle stands unrivalled. May my voice be listened to. From Montagnac to Nice, to Cannes, to Mentone, to Grasse, the distance is but small along the mountains, for the "Basses Alpes" join the "Alpes Maritimes."

THE BESSEMER SWINGING SALOON.

The readers of the "Practical Magazine" may recollect that in the number for September I ventured to express my fears that Mr. Bessemer would not succeed in effecting his object of overcoming that distressing malady sea-sickness by means of his swinging saloon. Unfortunately my anticipations have been confirmed from different quarters, and competent authorities in America and also in England predict a failure.

It has been determined as a physiological fact, by medical men who have directed their attention to the cause of sea-sickness, that it is not the result of the rolling of a ship, but is caused solely by the vertical motion, by the rising and falling of the vessel, or in other words by the pitching, during which the contents of the abdomen are forced to rise up against the descending diaphragm. Mr. Bessemer's saloon, although counteracting the rolling of the ship, participates in its general motion, and rises and falls with it, and therefore those travellers who are liable to sea-sickness will in all probability still suffer from it, whenever there is a sufficiently heavy sea on to cause the ship to pitch. The only alleviation to their discomfort will result from the saloon being placed amidships, where the motion of rising and falling will be less than at the bows or the stern. In the meantime those rich Englishmen who may fear to expose themselves to the disagreeable commotions of the Channel passage, have only to procure themselves Mr. Giffard's arm-chair, which, disposed in the saloon or on the deck of a steamer, will keep them steady and fixed in space, and will thus preserve them from the painful tribute which a turbulent sea exacts from so many unfortunate travellers.

MINOR TOPICS.

M. Chautard, dean of the faculty of sciences of Nancy, led by a happy idea, has been unexpectedly able to complete that splendid discovery of Faraday, the magnetization of light. He was studying the action exercised by powerful magnets upon the lines in the spectra of rarefied gases, traversed by the discharge from an induction coil or from a Holtz machine. The spectra which are characteristic of the matter through which the spark is sent present, under the influence of the magnet, certain very curious and special peculiarities for each, with regard to the position, fineness, and distance of separation, of the lines. Under the influence of the magnet the sparks from sulphur and from selenium suffer a notable diminution in intensity, so much so, indeed, that the spectrum sometimes disappears. Chlorine and bromine, on the contrary, are distinguished by an increase of intensity and by the development of numerous fine and brilliant lines, particularly in the green portion of the spectrum.

M. Treve, captain of the navy, has discovered an important fact—that when two bars of soft iron are placed side by side, surrounded by their magnetizing coil, and when one bar is charged, the other bar will also become charged by induction, and the charge of this second one is much greater than that of the first, in fact almost double. He was thus led to construct an apparatus of a similar kind to the Breguet exploder, but in which the auxiliary bars are made to produce the current destined to cause the explosion at a distance. This exploder has four coils, and has proved so efficacious that by its means charges were exploded in Marseilles from Paris.

M. Landrin has presented to the Academy of Sciences some samples of a new paper, of very fine quality and very strong. It is obtained from the fibres of the Gombo (*hibiscus esculentus*), a malvaceous plant, which grows in hot climates, particularly in Syria and Egypt, where it is much esteemed as a vegetable. But, besides this, the stalks can be made into excellent paper, and the seeds furnish a very useful oil, the residue of the extraction of which constitutes a valuable manure, containing 4·18 per cent. of nitrogen and 1·55 of phosphoric acid. Cultivated on a large scale, in Egypt for instance, this plant would give very large returns for the capital invested.

I regret to have to mention two very terrible accidents which have lately occurred, the fatal consequence of the extensive progress of manufacture on a large scale. At the sugar factory of Corbins, near Meaux (Seine-et-Marne), an evaporating and drying turbine, which rotated at the rate of 1,500 turns a minute, the greatest velocity yet attempted, suddenly burst with a formidable detonation, killing on the spot M. de Mastaing, chief engineer of the Fives-Lille Company, who, surrounded by his colleagues, was directing experiments with the new turbine.

At St. Denis, last Wednesday, 18th November, at 6.30 a.m., at the celebrated works of Messrs. Poirrier and Co., who are well known for their successful and extensive manufacture of the colours derived from aniline, a large retort containing a certain quantity of nitrate of methyle heated to a high temperature under considerable pressure, suddenly exploded with a fearful report, which was heard all over Paris, at Meudon, and even at Saint Germain. Nearly thirty of the women were more or less seriously burnt and injured, two have since died, and a few others are not expected to survive. The number of roofs injured and of windows broken is enormous. It is well that English ladies should know to what dangers poor workmen are exposed in preparing those charming and brilliant colours which serve to dye the dresses and ribbons which so delight the eyes. The green, the blue, the violet, the magenta, colours of which ladies are so fond, can only be obtained by the manipulation of highly dangerous, explosive, poisonous, and nauseous substances.

F. MOIGNO,
Canon of the Chapter of Saint Denis.

SMALL PRINTING PRESS ENGINE.

SOME weeks since I noticed an article in the "Scientific American," requesting a statement of the performances of small engines. A few years ago I built a small engine, which I set up in the "Herald" office in this place. The dimensions of the engine were as follows: cylinder 2 in. by 4 in., steam ports $\frac{3}{16}$ in. by 1 in., and exhaust $\frac{1}{2}$ in. by 1 in.; outside lap of valve was $\frac{1}{16}$ in.; no inside lap; throw of valve was $\frac{1}{4}$ in. The engine also had a link, the slot of which was 2 in. long. The main rod was 8 in. from centre to centre. The pin in the crosshead was $\frac{3}{8}$ in. in diameter, and the bearing of the main rod on crank was $\frac{3}{8}$ in. in diameter. The entire length of the bed plate was 2 in. The shell of the boiler was $\frac{1}{4}$ in. thick, and the heads $\frac{1}{8}$. The boiler was 3 ft. long by 1 ft. in diameter, with nine $1\frac{1}{4}$ in. flues. Half of the boiler and the flues made up the heating surface. The grate was 1 ft. square. The flame went under the boiler, and returned through the flues to the stack. The pulley on the engine shaft was 6 in. in diameter, over which a belt ran to a 16 in. pulley on a flywheel of 700 lbs. This wheel was belted to a line of $1\frac{1}{4}$ in. shafting, from which a large Potter newspaper press was run. The pulleys were of equal diameter from the fly wheel to the press. With 75 lbs. of steam, the engine, making 300 revolutions per minute, ran the Potter press, printing 1,000 sheets per hour, also a medium sized press, printing 1,200 sheets per hour. A small armful of wood and four bucketsfull of water was sufficient to run off the edition of 1,200 copies in a little over an hour. The water was pumped cold from a tank by a half stroke pump directly into the boiler. The exhaust steam was turned into the stack. Has the performance of this engine been beaten by any similar small engine? The edition was formerly worked off by four men, turning the large wheel by cranks, in four hours.

Delaware, O. FRANK C. SMITH.

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